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LIMES.

In the August Number of the TROPICAL AGRICULTURIST attention was called to the Bulletin of the Department of Agriculture which had been issued dealing with the cultivation of limes.

Interest in the possibility of lime cultivation in Ceylon has been shown and further enquiries have been made during the past few months for seed and for additional information.

The Government Agricultural Chemist has undertaken a series of analyses of lime fruits collected from various parts of the Colony and has drafted out some provisional estimates in regard to the possible costs of lime cultivation in Ceylon.

The Bulletin on Lime Cultivation, together with details of the recent analyses made, are included in our present number The information contained in these pages should be of interest and value. The estimates for opening areas in limes are also worthy of close investigation by those interested in the possibilities of new agricultural crops in the Colony.

The areas under limes at Anuradhapura Experiment Station continue to make steady progress and are at present in heavy fruit. The trees in the plot planted from British Guiana seed in December, 1917, are heavily laden with crops of good-sized fruit. The whole plot compares most favourably with the cultivations of limes which are now common in many of the West Indian islands, and the yields are expected to be most encouraging. There would appear to be little doubt that in suitable localities in Ceylon remunerative crops of limes could be raised.

It is not, however, recommended that large areas should be planted out before the crops from smaller areas have been ascertained with accuracy. Many of the Ceylon lime trees appear to be comparatively shy bearers, while reports from other quarters indicate that very good annual crops may be expected. Experiments should therefore first be made and prospective growers are recommended to proceed cautiously.

Concentrated lime juice can be made from small areas and it is not necessary to provide for the production of citrate of lime at the outset. If crops are satisfactory, extension can take place and the necessary equipment for a factory provided.

The area under limes at Anuradhapura is being extended. These are being grown on land which can in the very dry weather be provided with a small amount of irrigation. Limes require a fairly regular rainfall and if planted in areas that suffer from severe droughts only small fruits are produced.

Experience on the Anuradhapura Experiment Station has shown that the best results have been obtained when the plants have been planted out while small. They seem to withstand dry weather better. Seedlings that are about six months old have grown without any severe set-back, while larger plants have often died back before they have become established.

The Department of Agriculture will welcome further enquiries regarding lime cultivation and will undertake to secure seed for prospective cultivators if they are experiencing any difficulty in procuring seed from good strains of plants.

Orders for seed from the British Guiana limes now growing at Anuradhapura Experiment Station are being booked and are being filled in rotation. Many trees of country limes with handsome large fruits have from time to time been seen growing in various parts of the Colony and the citric acid content of the Ceylon-grown limes appears to be satisfactory.

Seed from heavy bearers of good-sized fruit should be selected and only the sturdiest plants from the nurseries put out in the plantation.

RUBBER.

FUTURE POLICY OF PLANTING OF RUBBER.

A lecture of the utmost interest not only to planters, but to all interested in the great rubber industry was delivered on Saturday morning, August 27, at the Ipoh Club, by MR. H. C. PINCHING, Mycologist, Rubber Growers' Association. The subject was "The Future Policy of Planting" and the report published below deserves the attention of all. The occasion was under the auspices of the Central Perak Planters' Association and therefore MR. E. L. D. EVANS, the Chairman of that body, occupied the chair. There was a fair attendance of members.

MR. E. L. D. EVANS briefly introduced MR. PINCHING who, he said, really needed no introduction from him. They had heard many addresses from MR. PINCHING before and he was sure the one he was going to give that day would be most interesting.

THE LECTURE.

MR. PINCHING said that under normal conditions there were two directions in which an industry could seek to effect a reduction in its cost of production with advantage to itself. Referring to the reduction in the costs of production he said that economy might even be carried to parsimony in an endeavour to secure cheaper production. Economy of that kind was often an extravagance. His paradox would be clear to anyone. They all know there has been notorious waste in the rubber producing world in the past; and if he had the money which, to his personal knowledge, had been wasted on only a few estates he would not be there that morning. Certainly we have to learn by experience but some wisdom had been dearly bought and even to-day there were many who still refused to profit by it. The second direction in which reduction of cost of production might be made was by increasing the output per unit of expenditure.

Their cost of production was found by dividing the total expenditure by the total output. An alteration in any of the factors would alter the cost of production. If the total expenditure was less, or if the total output were increased, the cost of production would be less. In the present state of the market they could not increase the total amount of output. But they should consider normal conditions. It seemed to him that the truest interests of an industry, so long as it was not a luxury industry, and its advancement could be best served by adopting a progressive policy and not only by every possible curtailment of expenditure. It was possible that there would be extra expenditure but they must look upon it as the sprat to catch the mackerel—the "sprat" of expenditure on account of better organization, up-to-date methods, scientific research—the "mackerel" of improved yields and hence cheaper output. They were living in hopes of a future for the rubber industry. They were hoping to have ere long a

market for as much rubber as they could produce at a reasonable figure. He thought that they would all agree that the future importance and enlargement of the industry—its future prosperity, if there is a future at all for rubber—depended upon its progress on lines indicated by scientific research rather than the mere exercise of rigid economy. It was of the lines of possible advance as were indicated by laboratory and field research that he wished to speak to them that morning. To get down to rock bottom the value of a rubber estate depended on its rubber producing propensities. The value was intrinsically bound up with its latex yielding capacity. In the early days the great cry was for acres opened up and trees planted. It was believed that the greater the number of trees per acre the greater the yield of latex. Experience had shown them that the early theory was wrong. The quality of the tree mattered much. Some time after the rubber boom was over and the cry for acres opened up had abated, it was noticed that some trees were finely developed while others were of meagre growth. This difference of growth could not be solely attributed to the soil and environment. It was felt that these differences were due to breed, or, in other words "heredity." Estate managers now took action to set apart well developed trees for seeds, or they preferred to get their seeds from well known estates. It was tacitly assumed that the best developed tree was the best latex yielder.

As more and more trees came into tapping, it was observed that, as there were differences in the build of different trees, so were there differences in the volume of latex yielded by different trees. The biggest and best developed trees were not necessarily the best latex yielders.

THINNING OUT.

In thinning out they all knew what they felt when they were confronted with a closely planted group of well-grown trees. They did not know which to take and which to leave. There ought to be only one consideration by which they should be guided: the biggest yielder should stand. He suggested a periodic census should be taken as was now done by some. The results would be astonishing. It was found that by far a greater percentage of the latex was given by a few trees. A census of 5,000 trees from eight to nine years old was taken and it was found that 80 per cent. of the latex came from a very small proportion (35%) of the trees; the other sixty-five per cent. of the trees gave only 20 per cent. of the latex. He himself had taken a census over 10 acres. Twenty-four per cent. of the trees were responsible for 56 per cent. of the latex; 47 per cent. of the trees were responsible for 29 per cent. of the latex and the remaining 29 per cent of the trees gave only 15 per cent of the latex. It would be found in most of the existing areas of rubber that a quarter of the trees gave three-quarters of the latex and that the remaining trees only a quarter. Looking at it from the business stand-point there must be some trees not worth tapping. Not only did quantity of latex from different trees show a great variation; quality also showed a great variation. Thus there might be a tree giving half a cup of good stuff and another giving three-quarters of a cup of poor stuff. Had they ever tried to work out the yearly yield of one of their trees?

He had found in the North a tree yielding at the rate of 50 lb. per annum. He had been up in Kedah recently and there he saw a tree which yielded 32 lb. per annum.

(A member interpolated that he knew an estate in Jeram which had a tree giving 150 lb.)

The lecturer showed that there was considerable variation in rubber contents from various trees and commented on the following two illuminating tables from WHITBY.

The first table gives variatiou in rubber content from 245 trees. The second shows difference of yield.

VARIATION IN CONTENT.

No. of Trees.	Grams of Rubber per 100 cc
4	24
2	24-25
7	26-27
11	28-29
16	30-31
27	32-33
1	48-49
4	50-51
3	52-53
2	54-55

RUBBER YIELD.

No. of Trees.	Grams per day.
55	1'5
84	2
140	4
4	25
2	26
9	27 & over

No thinking planter, MR. PINCHING continued, could close his eyes to the value of the question of the diversity of the rubber yield per tree as it might affect the value of existing fields and fields of rubber planted in the future. Yields of trees should be the basis of thinning out work. A volumetric record of each tree could easily be kept. This could be done with the help of a measuring cylinder or by getting a number of cups graduated in ounces or any other method of graduation. This work must be carried over some years at least, the record being taken once in 3, 4 or 6 months. Reliance should not be placed on one census alone, for often sickly trees gave extraordinarily big yields for a time. One fact, however, was irrefutable—that good yielders always remain good yielders and poor yielders always remain poor yielders. He was speaking of healthy trees.

Next he explained two methods of finding the actual amount of rubber produced by each tree per tapping and said that half a cup of good rubber was better than a full cup of poor rubber. The first method was by coagulating the latex in the cup: by putting a few drops of acetic rubber into a cup and afterwards weighing the rubber. The second was by the use of a metrolac. They had not now a metrolac sufficiently small for the purpose. He had written Home for a small instrument and he hoped that one might be sent out. There were two practical points which might strike some: the coolie element, for instance, some coolies were better tappers than others, and also the height of the cut. Nevertheless, if they kept on working for about a period of two years they would undoubtedly have a fair estimate of the respective value of each tree.

Recent investigations had shown that the quantity of latex was correlated in some way with the anatomical structure of the cortex.

The lecturer drew a diagram of the section of the bark. He said that investigations by BOBILOFF in Java would seem to show that the quantity of

latex depended upon six factors.

1. Number of latex rings
2. Breadth of the cortex
3. Width of the soft and hard portions
4. Ratio of the soft bark to the hard
5. Distribution of stone cells.
6. Completion or incompletion of the latex rings.

The following were taken from his results :—

	Big Yielder	Medium Yielder	Poor Yielder
Number of rings ...	28	9	2
Thickness of Bark ...	7·52	5·84	4·48
Width of Soft Bark ...	2 90	1·54	·76
Width of Hard Bark ...	4 52	4·20	3·64
Ratio of Soft Hard Bark ...	·64	·36	·20
Yield ...	98·4	10·9	·66

As far as could be seen at present these figures must be taken very generally. They could only be taken as indications of what we might expect. BOBILOFF himself thought that all that could be deduced from these anatomical investigations was the possibility of dividing trees into three lots : good, medium and poor. It had been suggested and put into practice in Java that there should be a microscopic examination of the anatomical structure of the cortex. Trees were planted about 200 to the acre and after about a year the planter went round, took a section of the bark and examined it.

MR. PINCHING next demonstrated how, with three or four chemicals and a hand magnifying glass, it could be done and said it was quite easy. The diversity of rubber yield raised the question whether seeds from well grown and finely developed trees will themselves produce finely developed trees. In 1914, at the International Rubber Conference at Batavia, it was shown that there was a remarkable similarity in the seeds from one tree. In nature one found cross-fertilization of *Hevea*, though both male and female flowers were found on the same tree. Generally the pollen was carried from other trees. It would seem from observations made that wind pollination of *Hevea* did not occur, and therefore the fertilization of the flowers was carried out through the agency of insects. It might happen that although we know all about the mother we might know nothing about the unknown male parent. Thus it was possible that those unknown characteristics might have a greater influence on the offspring than the known characteristics of the mother flower. To overcome this difficulty some had resorted to artificial fertilization so that trees both male and female were known to be good. That would, however, require considerable amount of care which he did not think planters would be ready to give. There was the much easier method of setting aside certain areas of rubber from which all the bad yielders and diseased trees had been cleared. Then a collection might be made of the seeds from the innermost trees in which the fertilization of the female flower was most probably by pollen from trees of desirable characteristics. Even if the seed had been selected they had no proof that the new plants which they got would be high yielders. Even if the latex yielding power of a tree was hereditary, would it appear in the very next generation? They had no right to assume that all the characteristics of the parent would appear in the offspring.

The lecturer next referred to MENDEL'S law and said that characteristics were often repeated in the second or third generation instead of the very next. Their knowledge of heredity in long-lived beings was meagre. Those who studied heredity dealt generally with rabbits, pigeons, mice and quickly flowering trees so that they might get results in one generation. Questions relating to man and to long-lived trees like the rubber were for generations. There was a problematical aspect therefore in reproduction by seed.

The question then arose whether there would be other methods of producing *Hevea*. There were two methods of reproduction : the sexual or the seed method and the vegetative method such as by cuttings, grafting and marcot. The lecturer had never been successful with cuttings. Luck never seemed to come his way. Though success had been attained as early as 1876 with cuttings from South America there was a report from the Royal Botanical Gardens, Peradeniya, Ceylon, in 1906 that out of 3,000 cuttings not one was a success.

The lecturer next demonstrated how a marcot was made : by ring barking the branch or stump and placing cow dung and clay around where the cambium is cut and wrapping the whole up with paraffin wax cloth. This method had an advantage over cuttings as the marcot continued to get its moisture from the parent plant.

Next the lecturer gave a practical demonstration of four methods of budding.

1. Forkert
2. Patch
3. Inverted T
4. Upright T

He said that plants raised by these methods had a propensity to put out branches because the buds were really branches of the parent tree. By cutting out these early branches a good straight trunk could be got.

In reply to a question, he said that he could not tell the respective merits of the four methods but he preferred the Forkert or the Patch because they could see what they were doing.

Further, in answer to a question, MR. PINCHING said that budding should be carried out on the field but marcots might be made in the nursery.

He next gave a demonstration of three methods of grafting.

1. Cleft, from which 40 per cent. of successes had been obtained in Java.

2. Side Grafting.

3. Crown Grafting from which 75 per cent. of successes had been obtained.

The processes were not difficult. A coolie can do budding at 30 trees in an hour.

It was possible to reproduce *hevea* by vegetative methods and it was reasonable to anticipate that the new trees would be heavy producing trees like those from which they were reproduced.

The lecturer next emphasized that by vegetative methods a new breed could not be produced ; they could only maintain a certain stock which they already had. If they wanted improvement they must go in for the sexual method,

In concluding the lecturer said that there was a small percentage of trees which stood predominatingly above the others as rubber producers and it would be a waste of time to worry about vegetative methods until they had found out those trees. He had often been asked the question by planters whether they should go in for budding and he asked them in return whether they had anything worth budding from. A record of the rubber yielding capacity of each tree was absolutely essential before vegetative methods could be resorted to. It seemed to him within the realms of possibility that with the ideas he had put before them that they could in the future be able to raise 2,000 lb. of dry rubber per annum from each acre. That would mean only 70 trees with each tree giving over 30 lb.

The lecturer next pointed out that 200 acres of such rubber would be much cheaper to maintain and more profitable to the owner than 800 acres of present plantation.—MALAYAN TIN AND RUBBER JOURNAL, Vol. X., No. 1 7

LIMES.

THE CULTIVATION OF LIMES.

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[*Department of Agriculture, Ceylon, Bulletin No. 49.*]

INTRODUCTORY.

There is a general desire in Ceylon for a new crop or crops to supplement existing agricultural industries. In cotton and sisal lie possibilities as crops for certain zones of the Colony, tobacco is capable of extension and improvement, while sugar-cane has a large opening if initial difficulties of capital can be surmounted. The cultivation of limes appears to offer good chances of success in the areas which receive a good rainfall.

Serious risks always have to be faced when attempts are made to establish a new crop, and, on the whole, limes probably need more careful consideration and forethought than the average tropical crop. The lime plant is extremely sensitive to drought and to excessive moisture in the soil; as is the case with most fruit trees, special protection from wind is necessary, and when grown under unfavourable conditions it is subject to severe attacks of insect and fungoid pests.

As much information as is available should be obtained before capital of any magnitude is invested in any new crop. In the case of limes, there is no previous experience in Ceylon from which definite information may be drawn. Individual lime plants are found in moist districts, and they appear to thrive well. The plant has, however, been regarded locally as a mere adjunct to the household, and the possibility of cultivating it on an estate scale has not been considered.

It is, therefore, necessary to draw upon the experience of other countries for information regarding this crop, supplementing the information by observing the conditions under which the plant thrives locally. A sound knowledge of agricultural conditions in the tropics will diminish the risk, but until trials have been made on a fair scale, there will remain a degree of uncertainty great enough to warrant caution.

THE LIME PLANT IN CEYLON.

The only systematic trial that is being made with limes as a cultivated crop is at Anuradhapura Experimental Station. Three plots have been planted. One of local limes, which are, in 1921, about four years old; one of limes planted from British Guiana seed, about the same age; and a larger area of local limes between one and two years of age. In addition, there are at this station plots of lemons, oranges, shaddocks, and grape fruit (pomelos). The total area of limes is in the neighbourhood of 14 acres.

Plates I. and II. show respectively the appearance of the orchard of mixed citrus fruits and that of the limes 3½ years old from British Guiana seed. Excepting for slight differences in shape of fruit and leaf, the imported lime does not appear to differ from the local variety.

The limes at Anuradhapura are most promising, in spite of the fact that the climate is rather dry for this fruit. The plants have given a small amount of fruit at 3½ years old, thus showing that they are probably slightly above the average in condition.

Very little disease has shown itself. In most countries scale-insects give more or less serious trouble on limes, and Ceylon will probably be no exception if the cultivation of this crop extends. So far, however, limes are less troubled by scales locally than is usual elsewhere.

To judge from individual plants, which are numerous in various parts of Ceylon, the lime appears to thrive up to 2,500 feet, provided the rainfall is adequate. The Southern Province and the Western Province are noteworthy in this respect, and, in all cases examined, the plants have been free from serious insect or fungoid attacks.

There are rumours of past serious attacks, and there seems little doubt that the plant has been subject to a fungoid disease of the stems (probably "pink disease" of rubber), but now these attacks are confined to other citrus plants, notably oranges, and the lime apparently escapes.

It is not wise to prophesy, nor is it possible to do so correctly, From observations on old plantations of this crop in the West Indies, there seems little doubt that, as the plants age, their resistance to disease lesse n and this tendency, which is popularly spoken of as "degeneracy," will probably be noted here. Early attention to drainage, cultivation, and protection from wind, however, lessens the danger considerably, and existing evidence seems to point to trouble of this sort being somewhat less in Ceylon than elsewhere.

The beneficial effect of organic matter on lime trees seems to be universally recognized in Ceylon, more so than is usual in other places. This is strengthened by a consideration of the poverty of Ceylon soils in leaf-mould, and supplies a useful hint to prospective growers.

There appear to be, as a rule, two fairly well-marked fruiting seasons for the lime in Ceylon ; one beginning in April or May, the other about October or November. Further observations on this point are, however, necessary in various parts of the Colony, and in any event small flushes are to be expected practically all round the year.

PRODUCTS OF THE LIME.

The products of the lime which are in demand in European and North American markets are as follows :—

Green Limes.
Pickled Limes.
Raw Lime Juice.
Concentrated Lime Juice.
Citrate of Lime (Calcium Citrate).
Essential Oil.

A prospective planter will, therefore, have to decide on the products which he intends to turn out. The demands of the market, the cost of manufacture, proximity to markets, and the capital available will influence the decision.

For the trade in green limes, specially selected fruit must be used, and care given to ensure efficient and attractive packing. The London trade is closely akin to the orange trade in the methods of packing employed. A fairly extensive trade exists in the West Indies, Dominica shipping to New York and London an average of 42,000 barrels of 1,500 fruits each (63 million limes) annually between 1914 and 1918.

The trade in pickled limes is a comparatively limited one at present, the output of Dominica, the largest producer, having at one time reached 1,500 casks of 2,000 fruit each, but having fallen in 1918 to 8 casks. For this trade yellow selected limes are steeped in several changes of sea water, and finally shipped in casks of sea water, to which some salt has been added.

Green and pickled limes do not seem to offer much opening as an industry for Ceylon, and for the present may be dismissed from consideration. It is possible that a very small local trade might be built up in connection with hotels and shipping, but the remoteness of the Colony from European and American markets makes the possibility of a large export trade slight.

Two classes of essential oil are obtained from the rind of the fruit: Hand-pressed oil or otto of limes is extracted from the rind before the fruit is crushed, the fruit being rolled by hand on a shallow spiked funnel known as an "écuelle," by which process the oil is pressed out; a power "écuelle," is on the market, which performs the work more rapidly. After the fruit has been crushed, a further yield of oil is separated from the juice by distillation.

Under any system of manufacture the hand-pressed oil or "otto" would be extracted, as the price is usually high. The distilled oil is of a lower grade and value, and can be prepared only where concentrated juice or citrate is being manufactured.

The trade in raw lime juice is chiefly carried on in connection with the makers of lime-juice syrups and cordials. As in the case of sugar-cane, the juice from the first crushing of limes is richer than that from subsequent millings, and shippers of raw lime juice usually keep the two millings separate. Special precautions regarding cleanliness and clarification are necessary in this trade, as naturally the appearance of the juice largely influences the price obtained.

Raw lime juice, if clarified by settling and straining and shipped in air-tight packages, will keep for a few months without serious loss of citric acid by fermentation. The presence of essential oil appears also to lessen the chances of loss of acid, so that on this account, as well as from considerations of colour and cost, raw lime juice is never distilled. Owing to the high price of otto of limes the fruits are, however, écuelled or hand-pressed before being milled.

Concentrated lime juice and calcium citrate (or citrate of lime as it is popularly called) are exported chiefly for use in connection with dye-works and pure chemicals. In both cases the operations involved in manufacture are for the purpose of reducing bulk and consequently freight. During the process of concentration the juice is usually reduced to a bulk from one-seventh to one-twelfth of its original volume, the degree varying with the strength of the mill-juice.

Calcium citrate is a compound formed by the combination of citric acid with lime or chalk. As it is insoluble in hot solution, the juice is heated before addition of the chalk. Cleanliness and careful drying are essential in this process. The bulk of citrate from a known volume of juice is usually slightly greater than that of highly concentrated juice, as the compound is light and bulky.

THE WORLD'S MARKETS.

The two countries which have hitherto supplied most of the exports of citric acid are Sicily and the West Indies. The Sicilian industry deals exclusively with lemon juice, both concentrated and in the form of citrate, while the West Indian one is confined to lime products.

In 1915 the Sicilian exports were valued as follows :—

	Rs.
Raw juice	393,294
Concentrated juice	69,624
Citrate of lime	8,035,467
Essential oil	4,141,365
Total ...	12,639,750

The island of Dominica, one of the British West Indies, has assumed the first place as an exporter of lime products. The figures for the four years 1915-18 are :—

	Total Crop in Barrels of 1,500 Fruit.	Value of Exported Products. Rs.
1915 ...	390,000	2,616,060
1916 ...	384,000	2,585,280
1917 ...	396,000	3,073,485
1918 ...	318,000	2,452,890

These two countries practically control the export market at present.

A certain amount of activity in the export of lime fruit has been exhibited lately by Cuba and Porto Rico, and in lemon fruit by Florida. In addition, Grenada, St. Lucia, Jamaica, and British Guiana in the West Indies have small lime industries, some of which are likely to grow.

The industry cannot be compared in magnitude to such staples as rubber or sugar-cane. The annual value of exports totals about Rs. 16,000,000, and there are about 12,000 acres involved in the Sicilian industry and 6,000 acres in the West Indian ones.

The Sicilian industry reached its highest point in 1908, and no further extension is possible there, while in any event the higher yield of citric acid per acre from limes and the absence of any need for precautions against frost make it fairly certain that we should look for future increases in the tropics and not in temperate climates. There is no immediate sign of increases visible, but Cuba, Porto Rico, and India are possible future growers.

The limits to which the markets can expand are not clear, and it is difficult to form any opinion whether a large increase in exports would entail a serious fall in prices. Lime juice for consumption, citric acid for

dyeing, and essential oil for perfumery and soaps are obviously of limited application, but to judge from the consistently high prices of the existing exports the limits of the markets have not yet by any means been reached.

CLIMATE AND SOIL.

Eighty inches of rain per annum are usually accepted as the minimum necessary for good lime estates. In Carriacou, a West Indian island, extentensive cultivation has been carried on with 60 inches, and in Grenada, by means of heavy mulching with grass and leaves, the Department of Agriculture successfully established a small area on 35 to 40 inches.

It may, however, be taken as a practical certainty that in dry places serious trouble with scale insects will occur. Eighty inches is a safe limit, although slightly less, if well distributed, will suffice. The safe upper limit is about 150 inches. With a rainfall above 150 inches the juice is dilute and expenses of manufacture greater, and, in addition, fungoid troubles of the root are likely to be more prevalent.

As in the case of other fruit trees, a rich loam on flat ground is the best for limes, but the plant with ordinary care will thrive on any soil of ordinary texture. Stiff clays are not suitable, and give rise to root troubles, but this class of soil does not appear to exist in Ceylon.

On steep hillsides, with the light sandy soil that is common in Ceylon, methods ot terracing and catch-draining are absolute necessities if the most profitable returns are desired. Apart from the loss caused by wash to the soil, the shallow root system of the lime makes it peculiarly susceptible to drought, and also likely to overturn if the covering surface soil is removed.

So far as the fruit is concerned, very little is removed from the soil by an ordinary crop of limes. The normal growth of the tree, however, makes the same demands on the soil as other plants of similar size, and the fertility of the soil should therefore be sustained.

Wind is one of the worst enemies of a lime plantation, both because of the shallow rooting system and because of the destruction of flowers. Situations exposed to strong winds are, therefore, not suitable, and even where the winds are moderate, an efficient system of windbreaks is necessary. The close association between the disappearance of scale insects and the existence of efficient wind shelter also makes this matter one of extreme importance.

THE SEEDLING.

With the exception of certain very marked varieties, such as seedless limes and spineless limes, there does not appear to be much external difference between individual trees. Differences in bearing power, habit, acidity of the juice, size of the fruit, and resistance to unfavourable conditions, however, do exist, and notice should be taken of these when choosing plants as suitable sources of seed.

The seedless lime is not common, and as it is necessary to propagate this variety by budding or grafting, it is unlikely to be popular. The spineless lime, on the other hand, presents the great advantage of convenience to the labour staff in such operations as pruning and reaping, and is a popular variety. The spineless variety arose in 1891 in Dominica as a "sport," and does not appear to exist in Ceylon but it is possible that a similar variation might occur here, and this should be kept in mind.

When the parent had been chosen, the seeds should be removed and washed carefully so as to clear away all pulp and juice ; washing on a sieve with a handful of fine ashes is the quickest and most convenient method. Removal of pulp and juice should be thorough, as otherwise the seed is liable to be harmed by fermentation, and, in addition, to be attacked by rats and insects. After cleaning, the seed should be thoroughly dried for a couple of hours in the sun ; longer exposure to the sun destroys germinative power.

It is not advisable to plant the seed "at stake" in the field, as the losses under these conditions are high, and the early growth of the seedlings is retarded. The customary method, which can be recommended, is to sow in carefully prepared beds, where weeding, watering, and shelter can be attended to ; the beds should be prepared as for vegetable gardening, and should be 5 feet wide, and the seed be sown in lines 8 or 9 inches apart, with an interval of 2 or 3 inches between the seeds in the lines. Twenty-five or 30 per cent. more seedlings than are required should be grown, so as to provide for losses in the field, and also to allow some latitude in discarding weakly plants.

At 4 or 5 inches high the strongest seedlings should be transferred to nursery beds, where they are set out 6 to 9 inches apart. It is customary to nip off the tops in order to produce a thick, well-branched tree. From these nursery beds the seedlings are taken to the fields when about 1 foot to 15 inches high, this stage being reached about ten months after the seeds are first planted.

FIELD CULTIVATION.

The first and most important point to be decided is the distance at which the plants should be set out. There can be no hard and fast rule. A well-grown and shapely lime tree in good soil will cover a circle of 15 feet diameter, while under adverse conditions 8 feet may be nearer the mark. On steep slopes the distance should be slightly widened to prevent overshadowing by the upper rows of plants.

The distance chosen should be such that when the trees are mature a clear avenue exists between the rows. This is necessary in the case of all fruit trees which produce flowers and fruit on the extremities of the branches and twigs, and which are hemispherical or spherical in shape. The necessity for pruning and for spraying is certain to arise in the case of limes, and a clear way for pumps and labourers is specially urgent with a spiny plant of this kind.

Under average conditions in Ceylon 15 feet would appear a suitable interval. Under even very adverse conditions, 12 feet is the minimum, and on good soil up to 20 feet may be necessary. Planting "square" allows less plants per acre than the quincunx or triangular system, and, in addition, is less natural when the shape of the tree is considered, so that the latter system is recommended.

Absolutely straight rows should be insisted upon. Apart from questions of appearance, straight rowing greatly facilitates field work, such as reaping, spraying, superintendence, pruning, etc., and this is more necessary in the case of the spiny lime than of most fruit trees.

Once the plants have been set out in the field, the question of keeping the intervals clean arises, as in the case of all slowly growing plants set at fairly wide distances apart. The lime begins to fruit at 3½ to 4 years old, and by 7 years may be regarded as in full bearing. For the first three years, therefore, the intervals are likely to be wide enough to allow of catch-crops without damage to the trees.

A system followed on one estate in Carriacou, West Indies, while not applicable without modification to Ceylon, is instructive. The limes were set out 15 feet apart, and down the centre of each interval was planted a single row of cotton (there a profitable crop); the cotton was then flanked on each side by a row of maize. The maize matured in 110 days, the cotton in six months; after reaping, the cotton plants were cut back and allowed to spring again, maize being again planted the next season.

This particular estate was run on model lines, and, apart from the profitable system of catch-crops, a noteworthy feature was the convenience attending the absolutely straight rowing. Reaping maize and cotton, spraying and pruning the limes, weeding and manuring could be carried out with the minimum of hindrance and expense.

The choice of catch-crops in Ceylon will naturally vary in each district. It is questionable whether the average Ceylon soil will stand severe cropping without harm to the limes. Two lines of manioc planted 5 feet apart down each interval would probably be both profitable and safe, and in some localities possibly one line of manioc flanked with maize or sorghum (dhurra) might be profitable. On poor land three lines of boga medalloa, as a green dressing, might have to be planted in place of a catch-crop.

It will probably not be possible to interplant perennial crops, such as rubber, with limes, as the latter needs sunshine for its flowering and fruiting. Permanent shade is never used, protection from wind being given by wind belts of large trees. Wind belts are, perhaps, one of the most important matters, and should be attended to early.

Mature limes are usually not clean-weeded, the intervals being kept under grass, which is regularly cut back. There seems to be some doubt as to the relative value of clean-weeding and grassing, but probably under ordinary estate management the latter will be found more convenient. On the light soils of Ceylon clean-weeding, particularly if accompanied by forking, would no doubt lead to heavy loss of soil.

Draining and terracing in the case of limes are governed by the same factors as control their use with rubber, and need not be dealt with here.

DISEASES AND PESTS.

The Mycological and Entomological divisions of the Department of Agriculture have investigated the diseases and pests of the lime in Ceylon.

Fungoid diseases appear to be extremely rare. The Pink Disease (*Corticium salmonicolor* B. and Br.) which attacks Hevea rubber and the Mildew (*Oidium Tingitaninum* Carter) both occur on oranges in Ceylon, and may be reckoned serious diseases of these plants; neither has, however, been officially recorded on limes.

"Scab" is a common disease on limes in Ceylon. It is caused probably by the fungus *Cladosporium Citri* Mass, and causes small, brown, rough, corky warts on the leaves, but the damage is apparently not serious.

Plate I.

ORCHARD OF MIXED CITRUS FRUITS, ANURADHAPURA EXPERIMENT STATION.

Plate II.

ORCHARD OF LIMES 3½ YEARS OLD FROM BRITISH GUIANA SEED
AT ANURADHAPURA EXPERIMENT STATION.

Among the insect pests which attack citrus plants in Ceylon, a few are found on the lime. The Citrus Leaf Miner (*Phyllocinstis citrella*) is a small moth, the caterpillar of which mines beneath the upper or lower epidermis of the leaf. Young lime plants are most commonly attacked, and the attack can be detected by the curling of the leaves and the silvery appearance of the tunnels. A mixture of crude oil or fish oil emulsion with tobacco extract is found efficacious for the pest in India.

Scale insects of different species and aphis also attack the lime, but their attacks are rarely severe in Ceylon, the insects being probably controlled effectively by parasitic fungi.

Fungoid pests are usually dealt with by surgical means, such as pruning, excision of bark, etc., and by spraying with Bordeaux mixture. Severe outbreaks of fungoid or insect disease are, however, almost invariably traceable to some unfavourable condition to which the tree is affected, and in such cases it is obvious that the surest methods of treatment are those which aim at remedying these conditions. As the matter is important, the question will be treated at some length.

In some cases a disease or pest may be regarded as the actual cause of the weakening of a plant. In other cases there seems little doubt that a tree weakened by some other cause provides a source of food preferred by certain kinds of insects, and on such a tree the insects may increase at a much more rapid rate than they would on a strong plant in normal health. This phenomenon is only just becoming a subject of investigation, and very few definite cases have yet been examined. In addition, there is the obvious fact that an outbreak of disease or a weak plant will be more destructive than an attack of precisely equal severity on a normal strong plant.

In the case of the lime, extreme poverty of the soil, exposure to wind, and deficiency of moisture appear to cause an increased liability to attack by scale insects, and several cases of successful treatment based on these facts are on record from lime-growing countries. Thus, it has become a recognized method of restoring deteriorated lime fields by interplanting windbelts of gliricidia, dhall, etc.

Common troubles arise from excessive soil moisture, fungoid root diseases, and diseases of the "collar" of the plant being the usual forms. In most cases these troubles can be overcome by attention to drainage. It is a matter of common knowledge to the planter that, excepting in certain cases, indirect methods of prevention, such as drainage, cultivation, pruning, manuring, etc., are both more effective and cheaper than direct methods, such as spraying and washing.

The control of insects attacks by parasitic insects or fungi has attracted a good deal of attention, and many cases are on record of successful results on a very large scale. These methods seem peculiarly applicable to citrus plants and to scale insects and aphis. Parasitic insects and fungi exist in Ceylon, and there seems little doubt that the remarkable freedom locally from severe scale insects attack of citrus plants is due to natural control of this nature. It is obvious that the method of natural control is cheaper and more efficacious than artificial methods, such as spraying.

THE CROP.

The yield per acre in Dominica is given as 150 barrels (of about 1,500 fruits each) on good soil under efficient management. The average for the Colony is below this figure, and on many estates the yield is as low as 100 barrels. No figures of yield for mature lime trees in Ceylon are available, so that it will be safer to assume the lower figure for ordinary unmanured cultivation.

A plantation of 100 acres of limes with ordinary care should yield, therefore, 10,000 barrels, with greater efficiency 15,000. The yield of juice varies according to climate from 7½ to 8 gallons per barrel, giving a total for the plantation of 75,000 to 112,500 gallons of raw juice.

Very little has been done accurately to record the effect of manures on this crop. The Dominica Department of Agriculture, however, carried out careful trials from 1913-17 and again from 1917 onwards, with the following results :—

DOMINICA.

Yield per Acre in Barrels of 4½ Cubic Feet.

	1914.	1915.	1916.	1917.
I.—No manure ...	23	53	62	88
II.—Five tons grass mulch ...	14	40	96	110
III.—Dried blood, 4 cwt. ...	17	71	98	141
IV.—Sulphate of potash, 1½ cwt.	6	28	40	70
V.—Sulphate of ammonia, 2½ cwt.	32	65	99	156
VI.—Basic slag, 4 cwt. ...	16	37	76	127
VII.—Dried blood, 4 cwt. ... Basic slag, 4 cwt. ..	28	89	126	167
VIII.—Dried blood, 4 cwt. ... Sulphate of potash, 1½ cwt. Basic slag, 4 cwt. ...	24	94	172	165

The fields on which these trials were made had been abandoned from 1895 till 1913. The effect of care on the yields is shown very strikingly in the figures above.

Every plot has benefited by the cultivation, pruning, etc., but the change has been much less in the case of the "no manure" plot. Even the potash plot (No. IV.), which had suffered most severely from neglect, rose in four years to seventy barrels. The percentage increase of crop in four years is as follows :—I., 283 ; II., 686 ; III., 730 ; IV., 1,067 ; V., 390 ; VI., 694 ; VII., 496 ; VIII., 588.

The later series gave the following results :—

	Limes 4 Years old. Trial A.		Trial B.		Limes 24 Years old. Trial C.	
	1917.	1918.	1917.	1918.	1917.	1918.
I.—No manure ...	56	184	41	89	120	129
II.—Mulch ...	95	274	72	170	103	92
III.—Sulphate ammonia Basic slag ...	96	235	27	120	110	210
IV.—Sulphate ammonia Sulphate potash ...	31	137	43	154	92	136
V.—Sulphate ammonia Basic slag ... Sulphate potash ..	63	236	27	154	180	240

Trials A and B show that by manuring we can bring the yield of young limes up to more than 150 barrels per acre. From trial C we learn that old limes should give over 200 barrels if well manured.

ESSENTIAL OILS.

Under any system of manufacture employed, it will be found profitable to extract hand-pressed oil before the limes are brought into the factory for crushing. Distilled oil, which is obtained from the juice after crushing, is, on the other hand, of a much lower value, and in certain cases may not be profitable.

Quotations in the London market during 1920 for lime oils were as follows :—

	Hand-pressed. Per lb.	Distilled. Per lb.
May ...	27*s.* 6*d.*	7*s.* 6*d.*
June ...	27*s.* 6*d.*	7*s.* 6*d.* to 7*s.* 9*d.*
July ...	25*s.* 6*d.*	7*s* 6*d.*
September ...	26*s.*	6*s.*

In common with other plants, the lime gives varying yields of essential oil according to the climate. The presence of essential oil lessens evaporation of water, and hence there is a tendency towards a higher yield of essence in dry localities. The West Indian Agricultural Department gives the yield of hand-pressed as varying from 3 oz. in wet localities to 4½ oz. in dry places per barrel of 1,500 limes, while from the same number of limes will be obtained on subsequent distillation a further 3 to 5 oz. of low grade essence. These yields would be equivalent to 28 to 42 lb. of hand-pressed oil and 28 to 47 lb. of distilled from an acre of average yield of 150 barrels of fruits.

The usual method for payment for hand-pressed oil on estates is by the ounce, and a skilful labourer will extract a pound or more a day, actually écuelling, therefore over 6,000 fruits. With an efficient mechanical écuelle the rate would be more rapid and presumably cheaper.

In the case of manufacture of concentrated juice and of citrate of lime, the whole bulk of juice from the mills is passed through the still. Where raw juice is being exported the scum rising to the top of the juice in the settling clarifier tanks is alone distilled, so that the colour and appearance of the juice may not be harmed by heating.

Distillation is usually carried on in an ordinary pot still with worm condenser and with direct heat. A Florentine flask is the most suitable form of receiver.

MILLING.

After the lime fruits have been écuelled to obtain hand-pressed oil (otto), they pass to the mill. Steel or iron rollers cannot be used where raw juice is being exported, as citric acid attacks iron, and the colour of the juice is spoilt, in addition to the fact that acid is lost by the chemical action.

Mill work in this industry is still rather primitive in many cases, which is an advantage for the planter newly embarking upon it. The simplest rollers are of wood covered with perforated copper sheet, the ragged edges of the perforations being outermost, so as to prevent the fruit slipping away from the grip of the rollers; the method of perforating the sheet is similar to that followed in making nutmeg or other graters from perforated tinned sheet. The mills usually consist of only one set of rollers, and the fruit skins from the mills are in this case often further pressed in a hand cider press to remove excess juice.

In better equipped factories rollers of ribbed or corrugated granite are used. These are stronger and more solid, and, as a rule, their work is better. Power can be applied by human or animal labour, by water power, or by steam or oil engine, in accordance with the size of the mills and the capacity of the factory.

The pressed skins form a valuable food for cattle, and are greedily eaten by these animals. In Dominica the whole of the skins are consumed by the working cattle of the estates.

CONCENTRATING THE JUICE.

Normal lime juice contains 12 to 14 oz. of citric acid per gallon of juice, and, excepting in the case of raw juice for cordials, it is sold on the basis of acidity. In the London markets quotations are for a "pipe," the standard pipe being 108 gallons of juice containing 64 oz. of citric acid per gallon, or, in other words, 6,912 oz. or 432 lb. of citric acid.

It is obvious that it is profitable to concentrate the juice before shipment, if fuel is obtainable at a reasonable cost. The West Indian figure for consumption of fuel is 1 to 2½ cords of wood to produce 52 gallons of concentrated juice (containing from 100 to 130 oz. of citric acid per gallon.) This means reducing about 500 gallons of raw juice to 52 gallons or 10 to 1. The degree the planter concentrates his juice is, therefore, influenced partly by the cost of fuel.

In the early days of the industry it was a common practice to concentrate to a content of 120 to 150 oz. acid per gallon, that is to boil down to 10 to 12 gallons of raw juice to one gallon of concentrated. The loss of acid through charring during boiling is, however, high, and the rate of loss is higher as the concentration increases. It seems to be fairly generally accepted now that concentrating to a content of about 100 oz. per gallon is most profitable, as at that point the extra freight on the bulk is compensated by the smaller loss of acid and the better price following on the improved appearance of the product.

Concentration is usually carried out in open "tayches" or sugar pans over direct fire, in a manner similar to the preparation of muscovado sugar, with the exception that the final pan in the battery is furthest from the source of heat in the case of lime juice. Direct heat and the use of iron pans give rise to a large proportion of impurities as sediment in the final product, in addition a loss of 7 to 8 per cent. of acid results even under careful working, and from 9 to 11 per cent. with ordinary work.

In 1915 trials were made with steam-heated wooden vats in St. Lucia, West Indies, and this method adopted commercially. The loss is lessened considerably and sediment reduced to one-tenth that of direct-heated juice. The steam-heated vat has also been introduced into the Government lime-juice factory in St. Lucia, and, as a result, a difference of £10 per pipe has been obtained in European markets apart from the reduced losses from charring.

MANUFACTURE OF CITRATE.

It is unfortunate that the term "citrate of lime" has crept into use. Calcium citrate is the correct term, and should be used to avoid confusion between lime (chalk) and lime (fruit).

If a solution of citric acid, such as lime juice, be treated with a base, such as lime (calcium hydrate), a compound, calcium citrate, is formed. This compound is insoluble in hot solution, and comes down in the form of a flocculent gray-white precipitate, which can be filtered off, dried, and shipped.

Upon treating calcium citrate with a strong acid, such as sulphuric, the citric acid is set free and calcium sulphate formed. The citric acid can thus be obtained pure by the dye works and other users.

The convenience of this method of treating lime juice is great both to the planter and the manufacturer. In addition, the loss of acid is less, the consumption of fuel is lower, and the product can be more easily standardized and packed. There seems little doubt that this product will eventually displace concentrated juice, but at present a demand for both exists, and this has led to equipment of factories handling both products, so as to take advantage of market fluctuations by manufacturing either at will.

In actual practice citrate is manufactured as follows. Juice from the mills is strained free from pulp and seeds, and then run into the still and essential oil distilled off. The hot juice from the still is then run into wooden cylindrical vats heated by an internal steam coil, and a solution of lime or chalk is gradually added until all the citric acid is precipitated as citrate. The calcium citrate then settles, the supernatant liquid is drawn off and filtered, and the citrate dried.

Cloth filter bags and presses are used to separate the citrate from adhering water as a rule, but much more efficient and rapid separation is obtained by spinning the water out by means of a sugar centrifugal, filter presses tend to press the citrate into lumps, whereas the centrifugal leaves it in an attractive powdery form. In both methods the citrate is then placed in hot air driers, and remaining water is removed.

The manufacture of citrate demands slightly more careful chemical control than does concentration of juice, but neither is complicated. It is obvious that brightness and cleanness is more important in the case of citrate, and straining, skimming, etc., are correspondingly thorough. In addition, some skill is necessary to add just enough and not too much chalk to each vat ; too much chalk means free chalk in the final product, too little means free acid, and neither should be present in well-prepared citrate.

The amount of chalk to be added is controlled by withdrawing small quantities of juice after each addition of chalk, and testing the amount of acid present by means of a standard solution of caustic soda. The details of this are simple, and can be learnt from any chemist and carried out by any intelligent person.

A rough test, which is useful, is to withdraw a small sample of the supernatant liquid and pour it on some chalk ; if effervescence takes place, the liquid is still acid, and more lime is needed. On the other hand, if, when the liquid is added to some lime juice, there is effervescence, it is obvious that too much chalk has been added.

A slight excess of acidity in the final product is preferable, as excess of lime or chalk in the vat is likely to throw down gums, which spoil the colour and texture of the citrate.

Thorough drying is very necessary, as, in the presence of excessive moisture, citrate ferments with loss of acid. Pure dry citrate contains 69·23 per cent. citric acid, but ordinary commercial samples have a lower proportion, although in no case should it be below 60 per cent.

The price fixed for calcium citrate during 1920-21 by the Italian Minister of Industry and Commerce is 1,000 lire (francs) per 220·4 pounds of citric acid. This corresponds to 3,060 francs for a "pipe" of 432 pounds of acid or 675 pounds of citrate.

THE FACTORY.

Comparatively simple machinery can be used for the first few crops or for a small acreage of limes, the complexity and efficiency of the factory being increased as the crop grows larger and profits increase. In the earlier days of the industry in Dominica, a beginner, when the crop of his estate reached the equivalent of 10 or 12 acres (1,500 to 2,000 barrels), would instal a handmill, two tayches, vats, and a copper still of 100 gallons capacity. £300 to £400 would cover the total cost, and the factory would be gradually extended as the crop increased.

In the majority of cases an estate would probably select concentrated juice as its chief product. Raw juice for export needs very careful attention to cleanness and quality, while calcium citrate needs more elaborate fittings and a higher degree of scientific control.

For a unit of 50 acres in full bearing, where concentrated juice was being turned out, the following are given as necessary in Dominica :—

Horizontal 3-roller (sugar cane) mill.
5-H. P. oil engine.
300-gallon copper still.
3 tayches (copper), 120, 150, 200 gallons.
2 1,000-gallon juice storage tanks.

Full particulars can be obtained by application to the Head Office of the Department of Agriculture, Peradeniya.

Great advances have of late years been made in the method of concentrating juice. Modern factories instal steam-heated vessels, which, of course, call for the addition of a boiler to the factory equipment. The vessels in use may be steam-jacketed and of copper, but the most useful type is of wood with a copper steam coil, and these wooden vats have given excellent results.

In a factory devoted to the manufacture of calcium citrate in place of concentrated juice, the preliminary process of écuelling, milling, straining, and distilling are the same. The tayches are replaced by heating vats for the neutralization process ; filters for the citrate and a special drying chamber fitted with shelves and an arrangement for a supply of hot air. As a complex factory is unlikely to arise in Ceylon in the early days of a lime-juice industry, it is unnecessary to deal with these in detail at present.

The consumption of fuel in both processes is high, and arrangements for a steady supply should form one of the first duties of a prospective grower and manufacturer.

G. G. AUCHINLECK.

APPENDICES.

I.—BIBLIOGRAPHY.

West India Bulletin: A quarterly scientific periodical by the Imperial Commissioner of Agriculture for West Indies, Barbados.

Annual Reports of West Indian Agricultural Departments: Issued by the Imperial Commissioner of Agriculture for West Indies, notably those for Dominica, Montserrat, St. Lucia, and Grenada.

Agricultural News: Issued fortnightly by Imperial Commissioner of Agriculture for West Indies.

Pamphlets 53 and 72 of Imperial Department of Agriculture for West Indies.

Tropical Agriculture: A book by H. A. A. Nicholls published by Macmillan & Co.

Bulletin of Imperial Institute: January-March, 1915.

II.—CHEMICAL CONTROL OF CITRATE MANUFACTURE.

It is of course not to be expected that the planter can devote much time to chemical control of lime-juice manufacture. It is a simple matter, however, to learn the method by which a rapid estimation of the percentage of citric acid in juice may be made. In a small factory it will not be possible to employ an analyst merely for necessary chemical control, and prospective makers of citrate are, therefore, recommended to pay some attention to the following notes.

For purposes of record and manufacture it is necessary to know the content of acid in juice, and if the best quality and price are desired, some form of chemical control is necessary. The following method, with care is satisfactory in the hands of an assistant of average intelligence.

TO ESTIMATE CITRIC ACID.

The following apparatus and re-agents are necessary :—

1 graduated burette, 50 cc. capacity.
1 flask conical (Erenmeyer) of 250 cc. capacity.
1 burette stand.
1 pipette of 5 cc. capacity.
1 bottle of standard (normal) caustic soda.
1 small phial of alcholic solution of phenol-phthalein.

The two last items can be made up by any analyst, the others are obtainable from druggists or from dealers in chemical apparatus.

Procedure.—Fill the burette to the top mark with solution of standard caustic soda. With the pipette withdraw it into the conical flask; dilute with its own volume of pure water, and add a few drops of the phenol-phthalein solution and mix by shaking gently. Now run into the flask a small quantity of caustic soda and mix by shaking; continue this until the juice attains a permanent faint pink colour. Read off the number of cubic centimetres of soda used.

100 cc. of normal caustic soda is equivalent to ·226 oz. of citric acid, so that the amount of citric acid can be easily calculated.

Example.—Juice withdrawn for testing 5 cc. Soda used for testing 6 cc.

100 cc. soda = ·226 oz. citric acid.

therefore 42 cc. soda = ·0136 oz. citric acid.

therefore in 100 cc. of juice there are $\frac{\cdot0136 \times 100}{5}$ or ·271 oz. of citric acid.

To convert ounces per 100 cc. to ounces per gallon, it is necessary to multiply by 45·43, so that the juice contains ·271 × 45·43 or 12·33 oz. per gallon.

CHALK AND LIME JUICE.

The reaction between citric acid and a solution or suspension of lime. is repeated as follows :—

Lime + acid = calcium citrate + water.

168 + 371 = 546.

That is, 168 parts by weight of pure lime (equal to 300 parts of chalk) are needed to combine with 378 parts of acid. A gallon of juice containing 12 oz. of citric acid would, therefore, require $\frac{12 \times 168}{378}$ or 5·3 oz. of pure lime

III.—QUOTATIONS FOR LIME PRODUCTS.

The following quotations for lime fruit products were taken from Lewis & Peat's, Ltd., Monthly Prices from February to May, 1921:—

Month.	Citrate of Lime.	Concentrated Juice.	Hand-pressed Oil.	Distilled Oil.
February	£28 per basis	£25 (nom.) per basis	15*s.* 6*d.* per lb. Fair to good	4*s.* per lb. Good water white
March	£28 per basis	£23 (nom.) per basis	18*s.* per lb. Fair to good	3*s.* per lb. Good water white
April	£28 per basis	£23 (nom.) per basis	19*s.* 6*d.* per lb. Fair to good	3*s.* per lb. Good water white
May	£28 per basis	£25 (nom.) per basis	21*s.* 6*d.* per lb. Fair to good	3*s.* per lb. Good water white

ANALYSES OF CEYLON LIMES.

M. KELWAY BAMBER, M.R.A.C., F.I.C., F.C.S.

The lime trees of the West Indies Citrus Medica var. acida, was said to have been introduced into tropical America from the East Indies, and was probably indigenous to the Valleys of the outer Himalaya and the mountain tracts of Central India. Cultivation has been carried on in Dominica and Montserrat from about 1844 and in later years in Jamaica, British Guiana, Trinidad, Grenada, Carriacon and St. Lucia. The most suitable situations for successful lime cultivation were rich well sheltered lands from sea level up to 800 feet, and with a rainfall of 80 to 160 inches per annum. They are however cultivated up to 2,000 feet with a rainfall of over 200 inches.

In 1912 there were 4,800 acres devoted to the lime Industry in Dominica alone including 1,500 acres not yet in full bearing, the total crop being estimated at 369,777 barrels of fruit, an average yield of 112 barrels per acre for the entire Island. The export of lime products from Dominica

in 1912 were valued at £96,673 consisting of concentrated juice 54½%, Raw Juice 18½%, Fresh Limes 10%, and Citrate of Lime 9¾%.

The manufacture of Citrate of Lime began in 1902 and steadily increased to 1911, the value per ton being £65 to £66 sterling, compared with £100 sterling in November, 1920.

Citrate of Lime is preferred to concentrated juice by the Acid makers as it is more easily worked and there is a considerable saving in freight casks and loss by leakage. The citric acid in citrate also fetches a better price, the present value of Citric acid being 2*s*. 7*d*. to 2*s*. 9*d*. per lb.

The essential oil of Limes is obtained by hand pressing and by distillation, the yield in practice being 1½ to 2 ozs. per gallon of the former though double this quantity is said to be available.

Distilled lime oil is obtained by distilling the juice, before the separation of Citrate of Lime, the yield being put at 4 lb. per 100 gallons of juice.

The value of the hand pressed and distilled oils, weighing approximately 8·7 lb. per gallon was about £2 17*s*. and 8*s*. 9*d*. per gallon, or 5*s*. 6*d*. and 1*s*. 5*d*. per lb. in 1912 compared with 20*s*. and 4*s*. 10*d*. per lb. respectively in November, 1920. The present price for hand pressed oil is 15*s*. 6*d*. per lb. and distilled oil 4*s*. per lb.

The average weight of the ordinary West Indian lime is 66·7 grams and 43·95 grams for the spineless variety, yielding about 60 per cent. of juice with 13·3 ozs. and 14·4 ozs. of Citric Acid per gallon respectively.

A number of analyses of lime fruits, of which there are two or more varieties in Ceylon have been made to ascertain the Citric Acid content compared with the West Indian figures.

Limes have been collected from different parts of Ceylon both during a long period of drought and after a period of wet weather to determine the effect of Climate. It was generally found that the proportion of juice was lower and the citric acid content rather higher in the dry period.

KANDY.

Kandy limes obtained on July 25th during a drought varied in size and ripeness. 400 limes weighed 14,230 gms. or 3 lb. 2·7 ozs. or an average per lime of 35·6 gms. or 1·26 ozs. Another lot of smaller limes averaged 28·4 grams or 1 oz. per lime.

The limes were cut, and the juice expressed yielded 4,320 cc. or 30% containing 14·3 ozs. of Citric Acid per gallon.

A considerable amount of juice still remained in the limes, especially the unripe ones, and a stronger method of expression was found necessary.

The juice was concentrated in a tinned copper pan, but the Citrate was badly contaminated with copper and purification resulted in a considerable loss on the original amount.

COLOMBO.

A further lot of 400 limes was obtained from the Colombo Market, which were said to have come from the Kandy District; these weighed 16,095 gms. or an average of 40 gms. or 1·42 ozs. per lime.

The 400 limes yielded 6,230 cc. of juice or 38% containing 13·44 ozs. of Citric Acid per gallon.

To obtain the maximum amount of Citric Acid the expressed limes were treated with 4,000 cc. or 0·88 gallon of boiling water and after standing 12 hours, again expressed, yielding 3,600 cc. or about 0·8 gallon containing 3·25 ozs. of Citric Acid per gallon.

This is equivalent to 870 cc. of original juice or a total yield of juice of 44·2% on the fresh limes.

The juice was concentrated to one-tenth volume, filtered and bottled. The concentrated juice was a dark brown colour but clear, and contained 73·12 ozs. per gallon, thus showing a heavy loss of Citric Acid during concentration.

A further lot of 1,000 limes from the Colombo Market, weighed 37,000 gms. (8 lb. and 2·4 ozs.) or an average of 37 gms. or 1·3 ozs. per lime. Cut up and expressed, they yielded 12,415 cc. of juice or 33·5% containing 13·7 ozs. of Citric Acid per gallon.

The pulp was treated with 8,000 cc. (1¾ gallon) of boiling water and again pressed immediately yielding 8,100 cc. 1·79 gallons containing 4·5 ozs. of Citric Acid per gallon.

This is equivalent to 2,660 cc. of original juice or a total yield of 40·8% on the fresh limes.

The juice was strained and heated to boiling in enamelled pans and the Citric Acid precipitated with lime water.

The 2,660 cc. of diluted juice was treated separately.

The Calcium Citrate separated well, and required 3 or 4 washings with boiling water to remove all colour.

The citrate from the dilute latex was very pure and rather lighter in colour than the first juices.

The total citrate obtained from the 1,000 limes giving 15,075 cc. or 3·33 gallons of juice was 1,551 grams or 3 lb. 6½ ozs. equivalent to 1·05 lb. per gallon of juice, compared with 1·18 lb. from West Indian limes. The drying of the Citrate took a considerable time, but unless done over steam there is a risk of the product being darkened. The citrate analysed, 61·6% Citric Acid.

KATUGASTOTA.

One lot of ordinary limes was received on 2nd. September, 1921, 99 limes weighed 5,157 gms. or an average of 51·5 gms. per lime.

Yield of juice 2,420 cc.=46·9 %

Citric Acid content 12·11 ozs. per gallon.

Kaffir Limes (Rough skinned) from Katugastota, received on 7th September, 1921. 100 limes weighed 6,538 gms. or 65·4 gms. per lime.

Yield of juice 1,700 cc.=26·0%

Citric Acid content 12·54 ozs. per gallon.

A second lot of Kaffir limes received on the 14th inst. averaged 51·5 grams per lime and yielded 46·9% of juice containing 12·1 oz. per gallon of Citric Acid.

GAMPOLA.

Limes sent by the Divisional Agricultural Officer. Two lots of 100 limes each of the ordinary, and Kaffir varieties were received on 11th. September, 1921.

Kaffir limes (Rough skinned). A.

98 Limes weighed 5,120 gms. or 52·3 gms. per lime.

Yield of juice 1,445 cc. or 28%

Citric Acid content 13·06 ozs. per gallon

Ordinary Limes. B.

60 Limes weighed 3,080 gms. or 51·2 gms. per lime.

Yield of juice 1,450 cc. or 47%

Citric Acid content 11·3 ozs. per gallon.

RUANWELLA.

A bag of limes, including the ordinary, Yakdehi, and Kuda Kudehi varieties was received on 8th. September, 1921. All but six limes were rotten having been damaged in transit.

6 ordinary limes weighed 330 gms. or 55 gms. each.

Yield of juice 100 cc. or 30%

Citric Acid content 12·1 ozs. per gallon.

BALANGODA.

Limes were received from MR. J. D. NICHOLAS, Balangoda, on 7th. July 1921, and were analysed for Citric Acid content.

The climate had been very dry for some weeks before the limes were gathered.

The limes were green and yellow and were sorted into medium size and small, the latter being rather riper than the large ones.

34 medium limes weighed 1,362 gms. or an average of 40 gms. each, while 61 small limes weighed 1,567 gms. or 25·7 gms. each.

The limes were cut and the juice expressed separately. Medium limes 1,362 gms. gave 736 gms. of juice or 54·38%; Specific Gravity 1·03 @ 30°/ 30° C. and containing 12·7 ozs. per gallon of Citric Acid.

Small limes 1,567 gms. gave 735 gms. of juice or 46·90%; Specific Gravity 1·04 @ 30°/30° C. containing 13·8 ozs. per gallon of Citric Acid.

The percentage of juice expressed is low due to the drought and the limes having partially dried before being analysed.

The amount of Citric Acid per gallon is about equal to West Indian limes which contain 12½ to 14 ozs. per gallon.

BADULLA.

100 limes received on the 14th. September, 1921, from the Agricultural Instructor.

Average weight of limes	...	58·6 gms.
Yield of juice	...	43·7 ,,
Citric Acid per gallon	...	11·1 ozs.

MATALE EAST.

100 limes received on the 23rd. September, 1921.

Average weight per lime	...	28·6 gms.
Yield of Juice	...	38·7 %
Citric Acid content per gallon	...	11·2 ozs.

KOTMALE.

100 limes received on the 17th. September, 1921.

Average weight per lime	...	29·7 gms.
Yield of Juice	...	39·0 %
Citric Acid content per gallon	...	11·2 ozs.

ANURADHAPURA.

A bag of Limes and Rough and Smooth Lemons were received from the *Dry Zone Experiment Station, Anuradhapura*. The limes were ripe and were rather larger than those from other districts.

Limes. 102 Limes weighed 4,640 gms. or about 43½ gms. each.
Rough Skinned Lemons. 16 weighed 3650 gms. or 222½ gms. each.
Smooth Lemons. 7 ,, 3002 ,, ,, 429 ,, ,,

The yield of juice and amount of Citric acid per gallon amounted to :—

	Juice.		Citric Acid. Oz. per gallon.
Small Limes	43 %	...	12·00 ozs.
Rough Skinned Lemons	27 ,,	...	6·80 ,,
Smooth Skinned Lemons	24 ,,	...	10·43 ,,

The yield of juice and Citric Acid content of the rough skinned lemons was poor and they would not pay for citrate manufacture. The smooth skinned lemons had a fair citric acid content, but the proportion of juice was low.

JAFFNA.

Limes received on the 8th September, from MR. COOKE, Farm School Officer, who reports that the local variety flowers all the year round, but principally in February and August and that the yield per tree varies from 800 to 1,000 fruits per annum.

198 limes weighed 8,972 gms. or 45·3 gms. per lime.
Yield of juice 4,100 cc.=45·7 %
Citric Acid content 11·20 ozs. per gallon.

TRINCOMALEE.

Limes (ordinary) from Trincomalee received on 30th. July, 1921.
100 limes weighed 3,702 gms. or 37·02 gms. per lime.
Yield of juice 1,676 cc.=45·4 %
Citric Acid content 14·6 ozs. per gallon.

The citric acid content is high compared with the Jaffna limes and the yield of juice about the same.

AVERAGE RESULTS OF CEYLON ANALYSES.

The following table shows the average weight, yield of juice and Citric Acid content of ordinary limes obtained during a long period of dry weather and after rains.

Dry Weather (July and August).

		Average Wt. gms.	Average Yield of Juice %	Citric Acid per Gallon
Balangoda Medium	...	40·0	54·4	12·7 oz.
,, Small	...	25·7	46·90	13·8 ,,
Trincomalee	...	37·0	45·40	14·6 ,,
Anuradhapura	...	43·0	43·00	12·0 ,,
Kandy	...	37·8	37·10	13·7 ,,
Average	...	36·7	45·30	13·4 ,,

After Wet Weather. (September and October).

Katugastota	...	51·5	46·90	12·10 oz.
Gampola	...	51·2	47·0	11·30 ,,
Ruanwella	...	55·0	30·0	12·10 ,,
Kotmale	...	29·8	39·2	11·20 ,,
Matale East	...	28·6	40·4	11·30 ,,
Badulla	...	58·6	43·7	11·10 ,,
Kegalle	...	54·5	53·1	12·54 ,,
	...			
Average	...	47·0	42·9	11·66 ,,

It will be seen that the average weight of limes gathered after rainy weather is considerably heavier than when grown during a drought while the citric acid content is lower by 1·74 ozs. per gallon.

The Kotmale and Matale East limes are poor in size and citric acid content, due probably in the former case to a cold and wet climate.

A certain number of limes from cultivated and selected trees have been collected during September and October and analysed, a summary of the results being given below :—

KELANI VALLEY.

Smooth skin limes from a tree in a cultivated garden said to give between 1,000 to 2,000 fruits annually.

The average weight was 63·8 gms. per lime, yield of juice 47·3 and Citric Acid content 12·2 ozs. per gallon, comparing favourably with average West Indian Limes.

PERADENIYA.

Several lime trees were examined in the Gannoruwa village. A lime tree is usually grown near the house and is surrounded by Cacao, Areacanuts, etc., grown under the usual village conditions, with no cultivation. Yields are said to be over 2,000 limes per tree and in one case from a tree 30 to 40 years old, three ordinary gunny bags containing over 1,000 limes each had just been sold, and the tree still carried flowers and fruits in different stages of growth.

Two average ripe limes from one tree weighed 80 and 63 gms. respectively. Forty ripe limes from another tree on the Experiment Station averaged 63 grams each and gave 53·2 % of juice containing 12·5 ozs. of Citric Acid per gallon.

200 ripe limes from another tree averaged 53·4 grams, and yielded 51·5 % of juice containing 12·2 ozs. per gallon.

The average weight per lime, yield of juice and citric acid content from these selected trees are shown in the following table.

District	Av. Wt. gms.	Yd. of Juice. %	Cit. Acid p. Gal. Ozs.
Kelani Valley ...	63·8	47·3	12·2
Gannoruwa ...	53·4	51·5	12·2
,, ...	63·0	53·2	12·5
Average ...	60·1	50·4	12·3

These compare favourably with the average weight, etc., of ordinary limes obtained during dry and wet weather viz., 41·8 gms. per lime yielding 44·1 % of juice containing 12·5 ozs. of Citric Acid per gallon.

The above figures point to the necessity of selecting the best fruit only from the most heavily bearing trees for seed purposes for any future planting.

LIME CULTIVATION ESTIMATES.

M. KELWAY BAMBER, M.R.A.C., F.I.C., F.C.S.

The yield per acre in the West Indies for well cultivated limes is about 150 to 160 barrels per annum, and from poor soils or less cultivated areas 80 to 100 barrels annually. The average for Dominica for 1912 was 112 barrels per acre. A barrel measures 4·55c. ft. equal to 3·55 bushels and holds from 1,200 to 1,400 fruits weighing nett about 150 lb. or 8 to 9 limes to the lb.

A barrel of limes gives 7½ to 8 gallons of fresh juice containing from 12 to 14 ozs. of Citric acid per gallon, equivalent to 8·4 to 8·8 lb. of calcium citrate (64% citric acid).

266 barrels, the average yield of 2⅔ acres, are required to produce one ton of citrate of lime, worth in July, 1921 about £93 sterling per ton. Citrate of lime is always sold per basis of 6 cwt. obtained from about 76 barrels of limes: the present value per basis being £28. From these figures one acre in full bearing planted 18 ft. × 18 ft. or 134 trees should

yield about 200,000 limes or 1,500 per tree. With a yield of 112 barrels per acre annually, giving 8·8 lb. of calcium citrate per barrel, a total yield of 985 lb. of Citrate may be expected worth at £93 per ton about £41 per acre.

Ceylon limes are generally smaller than the West Indian limes judging from the figures available to date, but all the limes examined have been from *uncultivated* trees, the yields of which are said to vary from 300 to 400 at high elevation to over 2,000 per tree at 1,600 ft. and below.

Limes gathered after a period of rainy weather are also found to be larger averaging 9 to the lb. compared with 8 to 9 for West Indian limes. Limes collected recently from cultivated gardens and from selected trees in villages are considerably above the average size being slightly over 7 to the lb. and are equal to the West Indian limes in yield of juice and Citric acid content. The aroma of these ripe limes is good, and yield of essential oil should be about normal.

The yield of juice obtained in the analyses has been below the full content owing to insufficient means of grinding and pressing, but it would approximate the same as West Indian limes under normal weather conditions and the content of Citric acid per gallon is also about the same viz., 12 to 14 oz. though some limes from higher elevations and cold wet climate have given only 11·2 oz. per gallon. In addition to the citric acid obtained as calcium citrate, the oil obtained by hand pressing the ripe fruits before expressing the juice amounts to 3 to 4½ oz. of oil per barrel, valued at about Rs. 15 per lb. In practice about 2 to 3 oz. of hand pressed oil per barrel are obtained. By distillation of the juice and skins before separating the citric acid, about 3 to 5 oz. of distilled oil are also obtained, worth from 2*s*, 6*d*. to 4*s*. 10*d*. per lb. With a yield of 112 barrels of fruit per acre the total handpressed oil would amount to about 21 lb. per acre, and the distilled oil from 21 to 35 lb. per acre.

The total revenue from a well cultivated acre of selected limes in full bearing in the West Indies would be approximately.

			£	*s*.	*d*.
	985 lb.	Calcium Citrate present value ..	41	0	0
Say	21 ,,	Hand pressed oil at £1 per lb. ...	21	0	0
,,	28 ,,	Distilled oil at 2*s*. 6*d*. ...	3	10	0
			65	10	0

The cost of opening 50 acres in Ceylon and bringing them into bearing in six years is estimated at Rs. 20,600 or Rs. 412 per acre. A West Indian estimate for Factory, Power and plant for a 50 to 60 acre estate is put at £1,520, but this would probably be increased at the present time, though some saving could be effected in Ceylon by using locally made granite rollers, fitted to second-hand rubber mills, and wooden storage and boiling tanks heated with steam coils, instead of the costly copper pans or tayches used in the West Indies for concentrated juice.

The following are the estimated costs of opening 50 acres in limes from jungle.

Clearing, Rs. 20 per acre ...	...	Rs. 1,000
Lining, Rs. 2 per acre ...	...	,, 100
Holing 2 ft. at 6 cents, Rs. 8 per acre	...	,, 400
Filling and planting, Rs. 8 per acre	...	,, 400
Roading and Draining, Rs. 15 per acre	...	,, 750
Plants, Rs. 5 per acre ...	...	,, 250
Supervision, Rs. 12 per acre ...	...	,, 600
Weeding 6 months, Rs. 18 per acre	...	,, 900
Fencing 3 strands Rs. 30 per acre	...	,, 1,500
Green Manures, Rs. 2 per acre	...	,, 100

	Brought forward	Rs. 6,000'00
Second Year.		
Weeding, at Re. 1'50 per acre, Rs. 18'00	Rs. 900'00	
Supplying, Rs. 2 00	,, 100'00	
Superintendence, Rs. 24'00 per acre ...	,, 1200'00	
Drainage and green manure, Rs. 4'00 per acre	,, 200'00	= Rs. 2,400'00
Third and Fourth Years.		
Weeding at Rs. 1'00 Rs. 12'00 per acre	,, 600'00	
Supplying ,, 1'00 ,, ,,	,, 50'00	
Superintendence ,, 24'00 ,, ,,	,, 1200'00	
Draining and Green Manure, Rs. 4'00 ,, ,,	200'00	= Rs. 4,100'00
		Rs. 12,500'00
Fifth Year.		
Cultivation, etc., including plucking, etc. Rs. 50'00 per acre	Rs. 2,500'00	
Pruning, boundaries, etc. Rs. 2'00 per acre	,, 100'00	
Manuring at Rs. 30'00 per acre ...	,, 1,500'00	= Rs. 4,100 00
Sixth Year at the same cost, Rs. 82'00 per acre		= ,, 4,100'00
Total cost of bringing into bearing without Factory or Rs. 412'00 per acre.		Rs. 20,600'00
The cost of a suitable Factory 100 ft. by 50 ft. is estimated at		Rs. 10,000'00
Machinery, including steam engine and boiler, Roller, Stills, Filters, Vats and Citrate drier, Water supply and packing		,, 16,000'00
		Rs. 26,000'00
Factory labour per day is estimated at 16 coolies at 50 cents		Rs. 8'00
Fuel for engine and drier, 4 yards at Rs. 1'50 ...		,, 6'00
Total ...		Rs. 14'00
300 days at Rs. 14'00 per day or Rs. 4,200 per annum.		
The total capital required on the above liberal estimate is		
Opening and bringing into bearing		Rs. 20,600'00
Fully equipped factory		,, 26,000'00
Factory labour and contingencies		,, 5,000'00
Total ...		Rs. 51,600'00
The cost of production from the 5th year onward for the 50 acres would be approximately		
Cultivation, Manuring and picking		Rs. 4,100'00
Factory labour, Fuel, etc.		,, 5,000'00
Transport and shipping of 10 tons at Rs. 90 per ton		,, 900'00
		Rs. 10,000'00

The average price of citrate of lime pre-war 1909-1912 was about £64 per ton. Distilled oil 2/6 per lb. and hand-pressed or écuelled oil 5/- or 6/- per lb. or higher, but the tendency since has been for a gradual increase in value on pre-war prices.

FRUITS.

FRUIT TREES AND THEIR ROOT TREATMENT

P. S. Govinda Rao, D.D.S., District Forest Officer, South Mysore.

Before discussing this question in its practical aspect, let me describe, for a little, the structure of the root of a tree. When a young plant is carefully taken out from loose soil and the soil is slowly washed away from the delicate branches of the root, it is rendered apparent that there is one region of each of these branches to which soil particles cling most tenaciously. This point or region is just behind the tip of each delicate branch of the root and usually extends for about an inch up the rootlet. This is the part that is able to take up water from the soil, because here are developed peculiar hairs which are termed root-hairs. These root hairs are best shewn if we grow a seed, between layers of wet blotting paper. The young roots, as they come out from the seed are seen to be covered with a white felt of hairs. These hairs are the true absorptive organs of the root. If such a root-hair is examined under a microscope, we see that it is a long thin sac lined with the living material (called protoplasm) and containing a clear fluid called cell-sap. Water from the soil can pass through the fine cell wall and the delicate living membrane. Thus the cell-sap becomes greater in volume and more dilute. A root-hair cannot hold an indefinite amount of this fluid and water is continually being passed on to the inner cells of the root. As soon as this water reaches the layer of young wood in the root it begins to ascend for the young wood is a system of pipes specially contrived by nature for the purpose of carrying water upwards. So, as soon as the water gets to this region of the young wood it begins to ascend, goes up the stem and finally out to the leaves. Some of the water is used up by the plant as it travels through these organs, and much of it is given off through the pores of the leaves. It is important to remember that the region of root-hairs is the only place on the root where water is absorbed. The other older and stronger parts of the root conduct water but do not absorb it. Anything, therefore, which injures the root-hairs interferes and affects seriously with the supply of the nourishing water to the plant.

This continual absorption, i.e., up-take of water from the soil, results in a considerable pressure being developed inside the root, forcing water up into the organs above. This root-pressure, as it is called, is one of the factors causing the ascent of water in plants. This can be clearly shown by a simple experiment. A young *dantu* plant may be cut off near the soil and a long glass tube fitted on the cut end by means of a rubber connection. A day after the experiment agoing you can see from the movement of the water in the tube how much water has been forced up. The pumping force of the root varies in different trees. It is said that, in the grape vine where the water has to travel a long distance, it can support a column of 39 inches of mercury.

With the above observation and knowledge on hand, it is easy to consider and understand what the conditions are in which the root-hairs can best fulfil their duties, what methods of treatment are rational, comparing these inferences with facts of our own and with others' experience. In the first instance, it is necessary to remember that the root-hairs and all the younger cells of the root proper are living cells and so require all that living matter stands in daily need of. Before these cells can do any work for the benefit of the rest of the plant, they must themselves be healthy. One of the first requisites for living cells is a free supply of good air. The roots must breathe. In nature there occur certain trees which have become adapted to life in swamps where the soil is close and where the water fills up all the soil interstices. These plants have special arrangements for the supply of air to their roots *(Avicennia alba* and *Avicennia Officinalis.)* The roots of these plants send up peculiar projections above the ground. These are breathing roots. They are full of porous tissue through which air easily passes to the roots in the mud, just as a diver in sea is kept in connection with the upper air by means of the tube attached to his helmet. This fact shows, rather reveals, the extreme importance of air to tree roots. The soil, therefore, in which the roots are situated must be of such a texture that there is a sufficient inter-change of the air in the soil and atmospheric air. The air contained in the soil is not exactly the same as that above the soil. Within the soil, oxygen (the life giving element of air) is always being used up for processes of decomposition of organic substances, and the roots are continually taking in oxygen and giving off other gases. The air of the soil is therefore as a rule poorer in oxygen and richer in other gases than the air above the soil. Here it must be said that there are various conditions that affect the permeability of the soil to atmospheric oxygen. Of these, the two most important are :—

(i) The size and degree of cohesion of the soil particles.

(ii) The amount of water in the soil.

With regard to the first point, if a soil is caked and hard although air may penetrate into the large crevices which are produced when such soil splits, still the inside of large masses of soil is insufficiently aerated. Small grained soil, after watering, tends to clog and cake like this. Larger grained soils cake less readily.

With regard to the second point, the condition of the ideal soil for fruit trees may be compared to that of fine sponge which has been soaked in water and thoroughly wrung out. Every part is covered with a film of water and yet the whole mass is permeated by air. Over-watering fruit trees has therefore two serious effects. In the first place, the spaces in the soil which should be occupied by air are instead filled up by water, and in the second place, the soil afterwards cakes and hardens, especially if it is all clayey, into an impermeable mass. It is worth while noticing here that the water in the soil which the roots absorb is not that which lies freely in the soil interstices, but the film of water which remains surrounding the soil particles when the excess has drained through. The root-hairs apply themselves closely to the soil particles and absorb this film. From this fact, a useful hint as to the subsoil of a fruit plantation is got at. It is most desirable that it should be of such a kind as to allow of good drainage. A laterite subsoil ensures the

passing through of superfluous water. A clay bottom means that there will be danger of water-logging. Thus two points of practical importance are arrived at. In choosing a site for a fruit garden, we must therefore see that the soil is of such a texture that is readily permeable to air and that the subsoil is of such a nature as to allow the draining off of superfluous water. If the soil and subsoil are not naturally of the desired consistency and character, still we can by special treatment bring about the conditions we desire to some extent at least. The texture of upper soil we can change by manuring and cultivation. Dry sandy soils need much bulky manures from the cow house or stable and there is scarcely any soil that will not benefit from green manuring. These organic manures increase the porosity of the soil, enhance its water-holding capacity and are themselves valuable additions to the plant food of the soil. Cultivation is essential both before and during the life of the plants. It has been again and again proved that deep and thorough ploughing and cultivation before planting the trees is an excellent investment of time, money and labour. With uncultivated land, it is well to do the first cultivation as much as a year ahead of the time of planting. During that period the land can be occupied with other crops which will give some return for the outlay, keep down weeds and maintain the looseness of the soil. On the spots where pits are to be made, however, there should be no crop during the three months previous to planting. The pits themselves and the subsoil removed from them should be exposed to air and light.

With regard to the subsoil, if it is not sufficiently porous, the defects should be remedied by means of proper drainage. If drainage is not arranged for, the effects of over-watering in such soils may affect very adversely indeed. In the case of orange tree, rotting of the roots sets in and the trees gradually die. Moreover, the water may rise again to the surface bringing with it subsoil salts and making the land salty and unfit for fruit trees. Such cases were brought to my notice for advice in Kadur and Tumkur District. In one case the remedy of promptly cutting drains remedied the defect and in the other case, the gratuitous advice was not availed of. In Mysore, I was shown some orange trees which developed a peculiar yellowing of leaves and a gradual death of the branches. The soil at the foot of trees in these patches was always occupied by succulent weeds of a type associated with salty conditions. The water of the well in the garden was not salty and the previous manuring was not such as to lead me to suspect that the disease could have been caused by it. On the soil being analysed, a large proportion of salts was revealed. It was then rendered apparent that the disease was due to increase in the salts of soil due to defective drainage. In this case, the digging of deep drains at intervals with an out-fall beyond the garden is the only current remedy.

To ensure a supply of free air to the roots of standing trees, it is essential that the soil round the trees should be broken up now and then to prevent caking. The breaking up process is best done twice a week after each watering. The hand pick (*kai gudli*) may be used for this operation. The top layer of soil should be pulverised to act as a porous mulch and a hand rake is excellent for this purpose.

Weeds growing under fruit trees have several serious effects on the roots. The roots of the weeds occupy the ground and interfere with the roots of fruit trees. Water is stolen by them which the fruit trees can ill-spare. The surface of the soil is blocked by them and the exhalation of

their roots serve to poison the soil atmosphere for the tree roots. The operation of breaking up the upper layers of soil to aerate the roots also removes the weeds, if properly carried out. In Tiptur coconut and mango gardens, and in a few mango gardens in Bangalore, thorough digging to one foot deep, as personally seen, has been of immense advantage and stimulated rich growth and caused extraordinary fruiting. It is necessary to see that the coolies do not injure trees while digging. The consideration of weeds under fruit trees naturally leads to the question of sub-crops.

The same principles must be observed here. Sub-crops must not interfere with the water-supply or aeration of the roots of the main crop. Close growing crops and long seasoned crops are therefore out of the question. While the fruit trees are young, brinjals, onions, chillies and other short season crops which are not close growing can be taken between them but these crops must not be planted close to fruit plants. It is a good rule that a circle having a diameter of about the breadth of the crown of the tree and a little over must be left clear round the base of each stem. Suppose we have planted out our fruit trees 15 feet apart each way and that the breadth of the crown of each tree is on the average two feet then we should leave a circle of 3 feet diameter clear all round the tree, unoccupied by sub-crops. The breadth of the crown of a tree in its early stages roughly corresponds to the area occupied by the roots. The next and succeeding years the dimensions of the trees will increase, and our area for sub-crops will correspondingly decrease, until when the crowns of trees are nearly in contact there is no space for sub-crops at all. It is important that the height of the sub-crop should be less than that of fruit trees since if the fruit trees are shaded by the sub-crop, then they grow long and lanky.

When the sub-crop is finally removed and the trees have to stand by themselves, this long and lanky stem proves to be weak and useless.

Let us now consider the life of a fruit tree from its seedling stage to its adult condition specially with reference to its root treatment, my present theme. Seeds are usually sown in pots or boxes or even in shady places in the field. Some fruit trees, such as guavas are generally grown direct from the seed and the others, which are grafted or budded, have their stocks from seed, so that the plants in their early stages may be considered as of one kind, whether grafted or not, later on. In the case of plants, such as mango stocks, the early life of which is spent as a rule in pots, special care of the roots is essential. In the first place there must be a hole in the bottom of the pot to allow of the draining away of surplus water. This hole should be covered inside by a piece of curved tile with the concave surface down to keep it open. Next to it should come a layer of dry leaves to ensure that fine soil is not washed down and the hole consequently blocked. On the top of this should come a mixture of medium sifted soil sand and leaf mould, in which the seed should be planted. Daily watering is necessary. The outside of the pots should be occasionally washed and scrubbed to allow of air penetrating the earthen ware, and the surface of the pots must be stirred or raked at least twice a week as said above. It must be remembered that the roots in a pot are in highly artificial and closed conditions and are therefore much more delicate than are roots in the soil of open ground.

For this season, plants should be taken out of the pots and transplanted to the field at the earliest opportunity. Let me quote here what a very experienced horticulturist writes:—"The way I advise mango seedlings to be grown is to dig a trench, say nine inches deep and in the bottom lay corrugated iron sheet, which should be covered with broken potshreds with the concave portions inverted. Over this a layer of coir of teased matting may be spread and then a layer of sand and leaf mould covered over, in which the seeds should be inserted. After germination the roots do not go beyond the layer

of corrugated sheet. The seedlings could therefore be removed easily without great injury to the pots used for grafting purposes or to their final quarters for growing as fruit trees." If plants in pots have been neglected and it is desired to revive them, then the plant must be carefully extracted from the pot with the ball of the earth adheriug to the roots. This earth should be carefully removed by washing. Dead, diseased and straggling roots should be removed by a sharp knife. Matted roots should be separated carefully and the main top root shortened (in trees which will stand this treatment). Mangos do not stand the amputation of the main root. Oranges and guavas do. Then the plant should be transplanted into porous gravelly soil in a pot and kept in a moist warm shady place till recovery begins. To keep up balance, a number of leaves on this plant should be cut off or a few branches pruned. While the plant is recovering, water should be given sparingly as the plant will not have yet developed new root-hairs to absorb it. Root-hairs which closely adhere to the side of the pot and the soil, are torn off in transplanting. To get new root-hairs, new roots must be developed. If much water is given before the formation of new absorbing roots, the roots will rot and all the labour taken will be in vain. When this plant begins to show signs of recovery and vigour, it may be removed to a slightly more exposed place and thus gradually accustomed to being brought back to its normal surroundings. The next question is :—How should the roots be treated in transplanting? The pit in the field should be dug fairly big about three feet each way. The pits should have been dug and left open to the air for some weeks previous to planting to aerate, *i.e.*, weather the sub-soil both in and out of the pit. Well exposed soil should be put in the bottom of the pit mixed with manure but manure should in no case be placed in direct contact with the root of the plant. Previous to putting in the plant, a stake should be driven in into the pit. To this, the plant will be tied. To put in the stake after planting, means that some of the roots will be injured. Before planting out fruit plants in their final places, it is well to harden them to their new conditions. If this is not done, the change may be so violent that the transplants will not survive. Many a failure has occurred in planting out mango plants that had been long in the nursery. It must be remembered that, in the nursery the plants will have been in a more or less shady spot protected from direct sun, from wind, and from extremes of temperature. In the field, it is in the open, gets the direct sun and has all the changes of temperature that are going. Moreover, the root system is always slightly injured in the transplanting process so that all the circumstances combine to make the plant lose water rapidly and replace it slowly. It is no wonder that, after a day, the leaves begin to droop and wither and that finally the whole plant dries up and succumbs. The process of gradually accustoming a plant to new surroundings is called *hardening*. One very simple method of hardening is to take the plant still in its pot out of the fields and plunge the pot in the soil near the place where it is to be transplanted. The plant should also be shaded during the first few days. The shade may then be taken off and the plant left sometime longer still in the pot. Finally, the plant should be taken out of the pot and transplanted into the pit prepared for it.

Before the plant is placed in the pit in position, the ball of roots with the earth should be gently teased out, and straggling and diseased roots removed. The plant should then be set on a little mound in the centre of the pit and the roots spread out over the gently sloping sides of this mound. It is a fatal error to have the base of the stem rammed down into the pit and the ends of the roots high up at the edge of it. The soil should now be thrown lightly over the roots and gently pressed down on and between them with a wooden peg. In transplanting, it is essential to bring about a compact connection between the roots and the soil, so that after further

addition of soil and further packing with the peg the whole surface may be trodden over several times and earth added till the plant is buried up to the same point as it was in the pot it previously occupied. A good soaking of the water should then be given. The shoot should be pruned, reducing non-essential branches by about a third of their length and retaining intact such as are necessary to make a good crown. The plant may now be tied to the stake. The string should not come directly into contact with the plant but should be padded with cloth or straw. When tying the string also, it should be brought once or twice between the plant and the stake to ensure a better and tighter binding and to keep the stake from rubbing on the plants. Tying the plant directly against the stake may result in the plant taking the form of the stake and in the case of a long irregular stake this would mean a most unsightly and useless trunk. The stake should be removed at the earliest possible safe moment, for if the plant gets to rely on the stake, it will become weak stemmed. Besides there is apt to be compression of the trunk at the points where the plant is tied to the stake.

In plants which are intended for further transplantation such as a nurseryman's stock, it is desirable to transplant several times keeping the long roots pruned in, so that there is a great number of short branches with many rootlets. This means that the whole absorptive system is in small compass and readily transportable. If the plant has to be carried some distance before being planted, the ball of roots and earth should be tightly tied up in sacking and steadied somehow during the transit. In trimming and pruning roots a sharp knife should always be used and the cut made in a sloping manner on the underside of the root.

The important feeding parts of the roots are the delicate tipes at the end of the root branches. They must not be injured. Hence the strong roots that conduct water from these feeding roots to the trunk should not be severed. One can, however, with safety remove these latter formed roots that occur on the main branches nearer the plant. It is wise to do this as the check on the plant without materially damping it is thus increased. It is also to be noted that old roots heal with difficulty and younger ones heal readily.

The degree to which the roots should be exposed is governed by the same principles. One does not wish to cause the delicate feeding-roots to wither up, so they are not to be exposed. The first two feet of the big roots can be exposed with safety in a ten-year old tree. The exposure and partial drying of these roots also acts as a check on water conduction.

On refilling the pits after a period of exposure, it is advantageous to place manure in the pit along with the replaced earth. It is very necessary to see that the manure is well mixed with the earth before replacing. Orange and other trees may not be pruned if making too rapid vegetative growth at the expense of their fruits but root-pruning should be resorted to only if the gentler method of root exposure fails to have the desired effect. In severe root-pruning, it may be necessary to cut some of the strong roots as well as the coarse lateral roots. The cut should always be on the underside of the root. It is usually unsafe to interfere with the tap root of big trees. It must be emphatically stated however that no amount of root-pruning will make up for a neglect of certain other common-sense precautions. In many gardens the owners expect fruit from trees that are crowded, shaded, and kept damp by a miscellaneous collection of other trees and plants. No root-pruning will take the place of system and can in the arrangement of fruit plantation. Another common belief is that some artificial manure will undoubtedly cause the trees to fruit. No artificial manure is of any use when the conditions of the garden are unhygienic. It is as if a man should demand medicine for a disease which is due to his refusal to wash himself.—MYSORE ECON. JOURN., Vol. 7, Nos. 7 and 8.

SOILS AND MANURES.

SOIL IMPROVEMENT.

ORGANIC MATTER.

Office of Organic Matter.—The restoration of an impoverished soil to a productive state usually is a simple matter so far as method is concerned. It may be a difficult problem for the individual owner on account of expense or time involved, but he has only a few factors in his problem. Assuming that there is good drainage, and that the lime requirement has been met, the most important consideration is organic matter. A profitable agriculture is dependent upon a high percentage of humus in the soil. Average yields of crops are low in most countries chiefly because the humus-content has been greatly reduced by bad farming methods.

Nature uses organic matter in the following ways :

1. To give good physical condition to the soil. The practical farmer appreciates the importance of this quality in a soil. Clayey soils are composed of fine particles that adhere to each other. They are compact, excluding air and failing to absorb the water that should be held in them. The excess of water finally is lost by evaporation, and the sticky mass becomes dry and hard. The incorporation of organic matter with clay or silt changes the character of such land, breaking up the mass, and giving it the porous condition so essential to productiveness. Improved physical condition is likewise given to a sandy soil, the humus binding the particles together.

2. To make the soil retentive of moisture. Yields of crops are limited more by lack of a constant and adequate supply of moisture throughout the growing season than by any other one factor. Decayed organic matter has great capacity for holding moisture, and in some measure should supply the water needed during periods of light rainfall.

3. To serve, directly and indirectly, as a solvent of the inert plant-food in the soil that is known as the "natural strength" of the land. Its acids do this work directly, and by its presence it makes possible the work of the friendly bacteria that are man's chief allies in maintaining soil fertility.

4. To furnish plant-food directly to growing plants. Even when it has been produced from the soil supplies alone, there is great gain because the growing crop must have immediately available supplies. Many of the plants used in providing humus for the soil are better foragers for fertility than other plants that follow, sending their roots deeper into the subsoil or using more inert forms of fertility.

The Legumes.—Any plant that grows and rots in the soil adds to the productive power of the land if lime is present, but plants differ in value as makers of humus. There are only ten essential constituents of plant-food, and the soil contains only four that concern us because the others are always

present in abundance. If lime has been applied to give to the soil a condition friendly to plant life, we are concerned with three constituents only, viz., nitrogen, phosphoric acid, and potash. The last two are minerals and cannot come from the air. They must be drawn from original stores in the soil or be obtained from outside sources in the form of fertilisers. The nitrogen is in the air in abundance, but plants cannot draw directly from this store in any appreciable amount. The soil supply is light because nitrogen is unstable in character and has escaped from all agricultural land in vast amount during past ages.

Profitable farming is based upon the great fact that we have one class of plants which can use bacteria to work over the nitrogen of the air into a form available for their use, and the store of nitrogen thus gained can be added to the soil's supply for future crops. These plants, known as legumes, embrace the clovers, alfalfa, the vetches, peas, beans, and many others of less value. They not only provide the organic matter so much needed by all these soils, but at the same time they are the means of adding to the soil large amounts of the one element of plant-food that is most costly, most unstable, and most deficient in poor soils. Their ability to secure nitrogen for their own growth in poor land also is a prime consideration in their selection for soil improvement, assuring a supply of organic matter where otherwise partial failure would occur.

Storing Nitrogen.—Man needs protection from his own greed, and nature's checks are his salvation. An illustration is afforded in the case of legumes grown for the maintenance of soil fertility. The clovers and some other legumes are seeded primarily for the benefit of the soil. The need of organic matter is recognized, and a cheap supply of nitrogen is wanted for other crops in the rotation. The purpose of the seeding is praiseworthy, but if all of the product were available for use off the land, observation teaches that the soil producing the crop probably would fare badly. The crops grown prior to the season devoted to legumes proclaim their need of better soil conditions, more organic matter, and more nitrogen, but the legumes appropriating nitrogen for themselves, give to the land a more prosperous appearance, and the disposition to harvest everything that is in sight prevails.

There is the excusing intention to return to the soil the residue from feeding, which should be nearly as valuable as the original material, while the fact usually is that faulty handling of the manure results in heavy loss, and the distribution of the remainder is imperfect. There is no happier provision of nature for the guarding of the soil's interests than the unavailability for man's direct use of a considerable part of most plants thus saving to the land a portion of its share of its products. The humus obtained from plant-roots, stubble, and fallen leaves forms a large percentage of all the humus obtained by land whose fertility is not well guarded by owners. This proportion is large in some legumes, amounting to 30 or 40 per cent. in the case of red and mammoth clover.

The Right Bacteria.—The word "bacteria" has had a grudging admission to the vocabulary of practical farmers, and reason is easily stated. The knowledge of bacteria and their work is recent and limited. They are many

in kind, and scientists are only in the midst of their discoveries. The practical farmer does well to let bacteriologists monopolize interest in the whole subject except in so far as he can provide some conditions that have been demonstrated to be profitable. The work of bacteria must come more and more into consideration by the farmer because nature uses them to produce a vast amount of the change that is going on around us.

In consideration of the value of legumes we must take into account the bacteria which they have associated with them, and through which they obtain the atmospheric nitrogen. This would be a negligible matter, it may be, if all legumes made use of the same kind of bacteria. It is true that the bacteria must have favourable soil conditions, but they are the same favourable conditions that our plants require. A fact of importance to the farmer is that the bacteria which thrive on the roots of some legumes will not serve other legumes. This is a reason for many failures of alfalfa, crimson clover, the soybean,the cowpea, hairy vetch, and other legumes new to the region.

Soil Inoculation.—The belief that the right kind of bacteria may be absent from the soil when a new legume is seeded, and that they should be supplied directly to the soil, has failed in ready acceptance because examples of success without such inoculation are not uncommon. Even if the explanation of such success is not easy, the fact remains that legumes new to a region usually fail to find and develop a supply of bacteria adequate for a full yield, and some of these legumes, of which alfalfa is an example, make a nearly total failure when seeded for the first time without soil inoculation. Experiment stations and thousands of practical farmers have learned by field tests that the difference between success and failure under otherwise similar conditions often has been due to the introduction of the right bacteria into the soil before the seeding was made.

Explanations offered for any phenomenon may later become embarrassing in the light of new knowledge. We do not really need to know why an occasional soil is supplied with the bacteria of legume new to it. We have learned that the bacteria of sweet clover serve alfalfa, and this accounts for the inoculation of some regions in the east. We believe that some bacteria are carried in the dust on the seed, and produce partial inoculation. Other causes are more obscure, The cowpea trails on the ground, and carries its bacteria more successfully than the soybean. Most legumes require a soil artificially inoculated when brought into a new region, failing otherwise in some degree to make full growth.

Method of Inoculation.—The bacteria can be transferred to a new field by spreading soil taken from a field that has been growing the legume successfully. The surface soil is removed to a depth of three inches, and the next layer of soil is taken, as it contains the highest percentage of bacteria. They develop in the nodules found on the feeding roots of the plants. The soil is pulverized and applied at the rate of 200 pounds per acre broadcast, If the inoculated soil is near at hand and inexpensive, 500 pounds should be used in order that the chance of quick inoculation may be increased. The soil should be spread when the sun's rays are not hot, and covered at once with a harrow, as drying injures vitality. The soil may be broadcasted by hand or applied with a fertilizer distributor. The work may be

done at any time while preparing the seed bed. The bacteria will quickly begin to develop on the roots of the young plants, and nodules may be seen in some instances before the plants are four weeks old.

Pure cultures may be used for inoculation. Some commercial concerns made failures and brought the use of pure cultures into disrepute a few years ago, but methods now are more nearly perfect, and it is possible to buy the cultures of all the legumes and use them with success.

Prices continue too high to make the pure culture attractive to those who can obtain inoculated soil with ease. If land has been producing vigorous plants, and if it contains no weeds or disease new to the land to be seeded, its soil offers the most desirable means of transferring the bacteria.

The claim is made by some producers of pure cultures that their bacteria are selected for virility, and should be used to displace those found in the farmer's fields. The chances are that, if soil conditions are good, the bacteria present in the soil are virile, and if the conditions are bad, the pure cultures will not thrive. All eastern land is supplied with red clover bacteria, just as some western land possesses alfalfa bacteria, and partial clover failure has causes wholly apart from the character of its bacteria.

We do not have definite knowledge concerning duration of inoculation nor the manner in which it is maintained when legumes are not growing, but we do know that when a legume has once made vigorous growth in a field, the soil will remain inoculated for a long term of years.—Farmers' Journal Vol. 3, No. 29.

NOTES ON THE MANURING OF PINE-APPLES IN QUEENSLAND.

ALBERT H. BENSON M.R.A.C.,

Director of Fruit Culture.

In spite of the advice that has been given by the Agricultural Department for many years respecting the manuring of pine-apples, many growers still fail to realise that the pine-apple plant requires special manurial treatment which will provide an ample supply of the essential plant foods in a form that will enable it to utilise them to the best advantage.

Experience has taught us that the success of pine-apple culture does not depend so much on the richness of the soil as on its being in a good mechanical condition and possessing good natural drainage. Such a soil is naturally warm, and if the situation is suitable is not likely to be subject to frost. The good mechanical condition of the soil encourages root formation, and if the soil has been well prepared, deep rooting; so that the feeding roots of the plant have a much larger area from which to obtain their supply of food than is the case when the majority of their feeding roots are near the surface.

Such a soil responds readily to the application of manure; consequently it is of the greatest importance to make sure that the manures applied to develop the pine-apple crop are applied in the right form and that they contain their plant foods in the proper porportions required by the plant.

Manuring carried out on any other lines is simply a waste of money, as it is no use to apply a manure containing an excess of one plant food and a deficieney of others. A manure containing an excess of any particular plant-food is not an economical one to use, especially where there is an excess of phosphoric acid, as the excess of this plant-food cannot be made use of, and as a result it is either washed out of the soil by heavy rain or, unless there is an excess of lime present, it forms insoluble salts of iron and alumina which remain in the soil in an unavailable condition.

The great fault with the majority of commercial fertilisers with respect to their suitability as a manure for pine-apples is that they contain a large excess of phosphoric acid that is not required by the plant and which is out of all proportion to the amount of its potash and nitrogen contents. As a result, such manures are bad buying on the part of growers as, on account of their badly balanced composition, they cannot be made use of by the pine-apple plant to the best advantage, and the grower has thus paid for a quantity of plant-food from which he will obtain no benefit.

Many commercial fertilisers, in addition to having a badly balanced ratio of plant foods as regards pine-apples, also contain these plant foods in the wrong form.

The pine-apple plant is very sensitive to any excess of acidity in the soil, and any such soils must have their acidity neutralised by the application of lime before they are fit to grow pine-apples; consequently the addition of acid phosphates, such as are contained in a commercial fertiliser in the form of superphosphate, only tend to increase the acidity in the soil and render it less suitable for pine-apple culture.

Commercial fertilisers containing superphosphate should therefore always be avoided as a manure for pine-apples, and growers should be careful not to purchase any fertiliser in which the phosphoric acid is said to be water-soluble on the tag attached to the bag or on the invoice. Phosphoric acid should be in the citrate soluble form, such as occurs in bones, meatworks manure, finely ground island phosphates rich in carbonate of lime, basic slag, or basic superphosphate, or it can be present in a less soluble form which will become slowly available. Growers should therefore see that the phosphoric acid as stated on the tag or invoice is citrate soluble or insoluble, the larger proportion being citrate soluble.

The potash contained in the fertiliser should be in the form of sulphate, if procurable, as experience has shown that in this form its use has proved very beneficial; at the same time, the use of the muriate or chloride has so far shown no ill-effects.

The nitrogen contained in dried blood, bone dust, or meatworks manure has given very good results, and when procurable dried blood is probably the best form in which to apply this plant food. The price is, however, very high, and sulphate of ammonia has, therefore, taken its place in the majority of

complete commercial fertilisers, and, when used in the right proportion, has given good results. Nitrate of soda is also a good form in which to apply nitrogen, but from my experience it is better to apply this manure as a top dressing by itself rather than to use it as a component part of a complete fertiliser. The growing of a green crop for the purpose of providing a supply of nitrogen must be watched very carefully, as there is always the danger of rendering the soil acid by turning in large quantities of green material which generates acidity during the process of decomposition. Should this take place, the addition of lime to the soil will soon correct the acidity.

Many manurial experiments were carried out by the Department some years ago on pine-apple growing on different classes of soils in the Brisbane District, and the result of those experiments is contained in the advice I have just given and the correctness of which has again been proved by a number of manurial experiments that have been carried out at Beerburrum both on the State farm and on soldiers' holdings, where it has been shown conclusively that the majority of commercial fertilisers contain far too great a proportion of phosphoric acid in comparison with their potash and nitrogen contents, and, further, that the application of phosphoric acid in the form of superphosphates or water-soluble phosphoric acid is distinctly injurious to the pine-apple plant and is the cause of "spiking" viz., the production of narrow leaves indicating the weakened vitality of the plant.

A complete manure in use at Beerburrum, which has given very good results, contains approximately 4 per cent. of phosphoric acid, citrate soluble, 14 per cent. of potash in the form of sulphate and 7½ per cent. of nitrogen in the form of dried blood, and this mixture is applied at the rate of 750 lb. to the acre during the months of August, September and February. If these figures are compared with those of any complete commercial fertiliser on the market, it will be seen how small an amount of phosphoric acid is used as compared with that contained in the commercial article, and what a large amount of nitrogen and potash is present. This shows conclusively that growers are wasting money by applying an excess of phosphoric acid to their pine-apple crops, and that the money so spent would have been much more profitably invested in the purchase of the nitrogen and potash that their crops needed.

The results obtained at Beerburrum bear out, as already mentioned, those obtained by this Department some years ago; and, further, they are in accord with the requirements of the pine-apple plant and fruit as shown by chemical analyses. A careful perusal of these analyses discloses the fact that the pine-apple plant and fruit require twice as much nitrogen and more than twice as much potash as they do of phosphoric acid.

Growers will therefore see that it will pay them to apply the right manure to their pine-apple crop, and that they only waste money by purchasing manures containing an excess of a plant-food which this crop is unable to make use of.—Queensland Agric. Journal, Vol. XVI, Part 3.

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PESTS AND DISEASES.

REPORT OF THE BOTANIST AND MYCOLOGIST FOR THE 3rd QUARTER, 1921.

The number of "in" letters was 714 and "out" letters 449.

The numbers of specimens sent in for examination during the third quarter was 333, consisting of 148 specimens of diseased plants, 59 specimens of fungi, and 126 specimens of flowering plants for identification.

Of the disease specimens sent in 53 were Hevea and 50 tea. The remainder included Acacia, Albizzia, Betel, Cacao, Cardamoms, Cassia, Coca, Coconut, Coffee, Dadap, Eucalyptus, Guava, Millet, Orchid, Orange, Paddy, Plantain, Rose, Sugar-cane, *Tephrosia candida*, Tobacco.

Of the Hevea specimens, thirty were cases of root disease, *Fomes lignosus* accounting for 14 and *Fomes lamaoensis* for 11.

Several cases of the leaf disease of tea caused by *Cercosporella Theæ* were recorded during the rains. In practically all cases this leaf disease begins on Acacia and spreads from the Acacia to the tea. The Acacias are defoliated, and the falling leaflets convey the disease to the neighbouring tea, in addition to the more normal distribution of the fungus by means of

wind-borne spores. *Acacia decurrens*, *A. dealbata*, and *A. melanoxylon* are all attacked by this disease. Several cases have been recorded in which it has occurred in firewood reserves on *Acacia decurrens* and has spread from that plant to interplanted *Eucalyptus robusta* (Red Gum), Karri (*Eucalyptus diversicolor*), etc.

New diseases recorded during the quarter include Black Rot, *Corticium Theæ* Bern., on Coca (*Erythroxylon coca*). Some root diseases of Cacao are under investigation.

The Botanist and Mycologist gave a lecture on Red Rust to the Sabaragamuwa Planters' Association in July, and on Flower-fly Traps to the Ceylon Natural History Society in September.

The Assistant Botanist and Mycologist has continued investigations into the Bunchy-top disease of Plantains, and has carried out an examination of the bark of the pedigree Hevea on the Experiment Station to determine the number of rows of latex vessels. He undertook the supervision of the London University examinations in practical botany in July.

The Assistant Mycologist has continued work on the Ceylon species of Phytophthora. On one rubber estate, an orchid, *Dendrobium Macarthiæ* was attacked by Phytophthora, at the period when pod disease was prevalent on the Hevea; the species is *Phytophthora Faberi*, i.e., the same as the Phytophthora on the rubber.

Both the Assistant Botanist and Mycologist and the Assistant Mycologist have taken part in the examination of the specimens sent in.

Visits have been made by the Staff of the Division to the Ratnapura, Madulkele, Kurunegala, Trincomalee, Negombo, Undugoda, Rambukkana, Nawalapitiya, Hambantota, Polgahawela, Avisawella and Colombo districts as well as to estates in the neighbourhood of Kandy.

T. PETCH,
Botanist & Mycologist.

PROGRESS REPORT OF THE ENTOMOLOGIST

July to September, 1921.

During this quarter the investigations mentioned in the last quarterly report have been continued as far as possible and of these special attention is being paid to the following pests :—Fringed Nettle grub (*Natada nararia*), tea termites (*Calotermes spp. and others*), the paddy swarming caterpillar (*Spodoptera mauritia*), the coconut caterpillar (*Nephantis serinopa*) and the spotted locust (*Aularches miliaris*). Drawings are being prepared to illustrate

the various stages in the development of several of the more important insect pests of the chief crops, and these illustrations are to be published in the Leaflet series of the Department, with brief accounts of the various pests and measures for their control.

The Entomologist went to the Eastern Province at the end of August to investigate an outbreak of the coconut caterpillar and to determine its status as a pest. This visit was made in response to a request by the local Plant Pest Board that this caterpillar should be declared a pest under the Ordinance.

As a result of this visit the proposal that the caterpillar should be declared a pest was submitted to the September meeting of the Estates' Products Committee for their approval. This being obtained, the matter was referred to Government, and the coconut caterpillar (*Nephantis serinopa*) has recently been declared a pest under the Ordinance by His Excellency the Governor in Executive Council.

The remedial measures which have been scheduled under the Regulations are the use of various kinds of light traps to attract the moths Plant Pest Boards will now be in a position to enforce the carrying out of these measures within their own districts whenever they consider it necessary.

During August the Entomologist visited an estate in the Wattegama District in connection with an outbreak of nettle grub ; the toona shoot-borer (*Hypsipyla robusta*) was prevalent in the toona plantation of this estate ; a visit was paid to an estate in the Rattota district to investigate the attacks of termites on tea bushes. The spotted locust (*Aularches miliaris*) was present in one tea field on this estate defoliating dadap, but not injuring the tea.

Reports have been received of the prevalence of tea mites on several estates during the quarter. The red spider, purple mite, and yellow mite were usually responsible for the injury.

Outbreaks of the scale insect (*Ceroplastodes cajani*) have been reported from three estates during the quarter as attacking Boga medalloa (*Tephrosia candida*). On one of these estates several acres of Boga had been very heavily infested, resulting in the dying back of a large percentage of the bushes. The infested area was being pruned. The scale was being partially controlled by parasites.

Several reports were received of the defoliation of dadaps by the large hairy caterpillar (*Taragama dorsalis*) ; the dadap shoot-borer (*Terastia meticulosalis*) continues to be prevalent on some estates.

J. C. HUTSON,
Entomologist.

AGRICULTURAL EDUCATION

SCHOOL AND HOME GARDEN AWARDS 1920-21.

The following awards have been made by the Department of Agriculture to the Government Schools which have done satisfactory work in School Gardens during the year 1920-21. These awards have been made on the recommendation of the Inspectors of School Gardens and in the Central, Southern and Northern Divisions in consultation with the Divisional Agricultural Officers.

School Gardens have improved in several districts during the year and arrangements are being made whereby teachers will receive regular assistance from Agricultural Instructors as well as from Inspectors of School Gardens.

A very large distribution of vegetable seed has been made to all Government Schools with School Gardens during the past three weeks and additional funds have been secured for the purchase of implements for School Gardens during the financial year 1921-22.

The Home Garden movement has progressed during the past year and additional funds will be available during the present financial year for awards to those pupils who have creditable Home Gardens.

Too much stress cannot be made upon the importance of work in School Gardens attached to vernacular schools and in the teaching of nature knowledge from the objects grown in these gardens.

Monetary awards to schools for School Garden work are distributed amongst the assistant teachers and the pupils, whilst awards for Home Gardens are personal to the recipients.

Competitions amongst School Gardens are being organised and offers of prizes have already been received for these competitions from persons interested in the School Garden movement.

The number of Government Vernacular Schools at which School Gardens have been registered now totals 431 and are distributed as follows :

Kandy District	...	...	49
Nuwara Eliya District	...	...	15
Matale District	...	...	16
Kegalle District	...	...	26
Kalutara District	...	..	39
Galle District	...	...	27
Matara District	...	..	29
Hambantota District	...	...	21
Anuradhapura District	..	...	22
Mannar District	...	...	3
Mullaitivu District	...	...	5
Trincomalee District	...	...	2
Colombo District	...	...	41
Kurunegala District	...	...	55
Puttalam District	...	...	8
Chilaw District	...	...	9
Ratnapura District	...	...	30
Uva Province	...	...	24
Batticaloa District	...	..	10

F. A. STOCKDALE,
Director of Agriculture.

25th October, 1921.

AWARDS TO SCHOOL AND HOME GARDENS, SEPTEMBER, 1921.

Central Division.

School Gardens.

Kandy District.

Name of School.	Name of Teacher.	Award.
Idamagama, B. V. S.	M. G. S. de Silva	Certificate and Rs. 20·00
Nugawela, B. V. S.	D. M. U. Banda	,, ,, 20·00
Gunnepanna, G. V. S.	D. J. Rupesingha	,, ,, 20·00
Mahamedagama, B. V. S.	P. U. Banda	,, ,, 20·00
Mediwaka, B. V. S.	D. Banda	,, ,, 15·00
Doragamuwa, B. V. S.	D. G. Henderick	,, ,, 15·00
Gunnepanna, B. V. S.	W. M. A. Weerasingha	,, ,, 15·00
Paranagama, B. V. S.	W. W. Perera	,, ,, 15·00
Uduwa, M. V. S.	W. P. Ratnayaka	,, ,, 15·00
Giriulla, B. V. S.	N. Nagiris	,, ,, 15·00
Talatuoya, B. V. S.	R. M. D. Godamune	,, ,, 10·00
Bhutawatte, B. V. S.	W. R. S. Kahalakalawe	,, ,, 10·00
Hanwella, B. V. S.	A. M. Appuhamy	,, ,, 10·00
Hindagala, B. V. S.	P. B. Kehelgamuwa	,, ,, 10·00
Haloluwa, B. V. S.	K. K. D. N. Nanayakkara	,, ,, 10·00
Nugawela, G. V. S.	E. B. Senewiratna	,, ,, 10·00
Ginigathhena (Yati-ganhulaha), B. V. S.	H. M. Siyatu	Certificate
Menikdiwela, B. V. S)	M. B. Petiyagoda	,,

Nuwara Eliya District.

Pundaluoya, B. V. S.	B. U. K. Banda	Certificate and Rs. 15·00
Wataddora, B. V. S.	K. G. F. Karunatileka	,, ,, 15·00
Kadadora, B. V. S.	G. G. Appuhamy	,, ,, 10·00
Madulla. B. V. S.	K. B. Ratnayaka	,, ,, 10·00
Kalaganwatta, B. V. S.	P. B. Weerasingha	Certificate
Pallebowala, B. V. S.	M. A. M. Perera	,,
Morape, B. V. S.	W. S. de Silva	,,

Matale District.

Yatawatte, B. V. S.	P. Punchirala	Certificate and Rs. 10·00
Madawala-Ulpota, B. V. S.	R. T. Banda	Certificate.
Madipola, B. V. S.	P. W. D. Banda	,,

Kegalle District.

Beddewela, B. V. S.	A. H. B. Madawala	Certificate and Rs. 20·00
Mawanella, A. V. B. S.	R. M. Perera	,, ,, 15·00
Galapitamada, B. V. S.	N. W. S. Wijeratna	,, ,, 15·00
Bosella, B. V. S.	M. D. Premasuriya	,, ,, 15·00
Maniyangama, B. V. S.	S. A. Perera	,, ,, 10·00
Nilwala, B. V. S.	D. H. Ranasingha	,, ,, 10·00
Ambepussa, B. V. S.	James Siuno	,, ,, 10·00
Getiyamulla, B. V. S.	W. Amarasena	,, ,, 10·00
Beddewela, G. V, S.	L. Pinto	,, ,, 10·00

Home Gardens.

Kandy District.

Name of School.	Name of Pupil.	Award
Mediwaka, B. V, S.	J. G. Punchi Banda	Certificate and Rs. 5·00
Mahamedagama, B. V. S.	G. Punchi Banda	,, ,, 5·00
Gunnepana, G. V. S.	W. Dingiri Amma	,, ,, 5·00

Nuwara Eliya District.

Pundalu Oya, B. V. S.	A. Delpitiya	Certificate and Rs. 5·00
Wataddora, B. V. S	M. M. Perera	,, ,, 5·00

Kegalle District.

Mawanella, A. V. B. S.	R. W. A. M. Heen Banda	Certificate and Rs. 5·00
Beddewela, B. V. S.	P. Siyatu	,, ,, 5·00

Southern Division.

School Gardens.

Kalutara District.

Name of School.	Name of Teacher.	Award.
Alutgama, B. V. S.	G. P. Abeysekera	Certificate and Rs. 15·00
Warakagoda, B. V. S.	M. D. Charles	,, ,, 15·00
Handapangoda, B. C. S.	M. D. Williams	,, ,, 15·00
Paragastota, M. V. S.	James Peiris	,, ,, 15·00
Tudugala. B. V. S.	D. P. Ranaweera	,, ,, 15·00
Walallawita, B. V. S.	A. Munasinghe	,, ,, 15·00
Botale, M. V. S.	D. D. R. Manamperi	,, ,, 15·00
Lathpandura, B. V. S.	D. F. Manamperi	,, ,, 15·00
Tantirimulla, B. V. S.	D. H. Kannangara	,, ,, 10·00
Kulupana, B. V. S.	D. J. Pulleperuma	,, ,, 10·00
Ilimbe B. V. S.	W. Kirineris	,, ,, 10·00
Bopitiya, B. V. S.	B. D. Leyaris	,, ,, 10·00
Govinna, B. V. S.	P. S. Perera	,, ,, 10·00
Kevitiyagala, B. V. S.	W. S. S. Wijayatilleka	,, ,, 10·00
Migahatenna, B. V. S.	S. H. D. S. Jayasekera	,, ,, 10·00
Galpata, B. V. S.	I. D. Perera	,, 10·00
Bellana, B. V. S.	H. A, Perera	Certificate.
Liniyawa, M. V. S.	D. G. Abeyasinghe	,,
Uduwa, B. V. S.	Don Sarnelis	,,
Uduwara, B. V. S.	D. C. Amarasinghe	,,
Remune, G. V. S.	M. Manamperi	,,

Galle District.

Niyagama, B. V. S.	W. P. Wijesinghe	Certificate and Rs. 15·00
Telikande, B. V. S.	D. K. Mahaliyane	,, ,, 15·00
Kimbiya, B. V. S.	W. D. Cornelis	,, ,, 15·00
Bussa, B V. S.	A. J. E. de Silva	,, ,, 15·00
Horadugoda, M. V. S.	D. U. Samaratunga	,, ,, 15·00
Polpagoda, M. V. S.	H. L. Endoris Silva	,, ,, 15·00
Magedera, M. V. S.	S. A. Kodituwakku	,, ,, 10·00
Hungantota, B. V. S.	H, E. Manis de Silva	,, ,, 10·00
Walpita, B. V. S.	P. R. Senewiratna	,, ,, 10·00
Gonagala, B. V. S.	D. W. Welaratna	,, ,, 10·00
Ihalagoda, B. V. S,	B. C. Wijayapala	,, ,, 10·00
Yatagala, B. V. S.	S. M. Abeysekera	Certificate.

Matara District.

Name of School.	Name of Teacher.	Award.
Narandeniya, B. V. S.	T. D. Nicholas	Certificate and Rs. 20·00
Owitigamuwa, M. V. S.	M. Carolis	,, ,, 20·00
Kotapola, B. V. S.	P. F. Abeywickreme	,, ,, 20·00
Marambe, B. V. S.	H. D. Silva	,, ,, 15·00
Karagoda, Uyangoda, B. V. S.	D. D. Dias	,, ,, 15·00
Tihagoda, B. V. S.	D. H. de Silva	,, ,, 15·00
Bamunugamuwa, B. V. S.	K. P. Kulasinha	,, ,, 10·00
Talpawila, B. V. S.	N. Samarasinha	,, ,, 10·00
Bopagoda, B. V. S.	W. H. U. de Silva	,, ,, 10·00
Beralapanatara, M. V. S.	D. A. Wickramasinghe	,, ,, 10·00
Alapaladeniya, B. V. S.	H. G. Charitananda	,, ,, 10·00
Rotumba, B. V. S.	D. D. W. Goonesekere	,, ,, 10·00
Pallegama, B. V. S.	L. Kavenis	Certificate
Dampella, B. V. S.	D. D. Andravas	,,
Paraduwa, B. V. S.	S. D. Bastian	,,
Morawaka, M. V. S.	D. Abeywickrema	,,
Deiyandara, B. V. S.	A. H. J. de Silva	,,
Atureliya, M. V. S.	Odiris de Silva	,,
Aparekka B. V. S.	D. A. Abeywickrema	,,

Hambantota District.

Mandaduwa, M. V. S.	B. Jayasekera	Certificate and Rs. 15·00
Nihiluwa, B. V. S.	D. B. Senarath Yapa	,, ,, 15·00
Rauna, B. V. S.	D. Hetthewa	,, ,, 15·00
Warapitiya, B. V. S.	M. Hendrick	,, ,, 15·00
Walasmulla, B. V. S.	K. Byes	,, ,, 10·00
Tissamaharama, B. V. S.	Jayasekera Don Cornelis	,, ,, 10·00
Middeniya, B. V. S.	Thomas Appu	,, ,, 10·00
Mulana, (Angunakolaperessa)	B. D. Edirisuriya	,, ,, 10·00
Nakulugamuwa, B. V. S.	D. S. Wickramasinghe	,, ,, 10·00
Palatuduwa, M. V. S.	D. P. Ferdinando	Certificate
Talawa, B. V. S.	J. P. S. Abeyakoon	,,

Home Gardens.

Kalutara District.

Name of School.	Name of Pupil.	Award
Walallawita, B. V. S.	Punchi Singho	Certificate and Rs. 5·00
Alutgama, B. V. S.	Don Simon	,, ,, 5·00
Nauttuduwa, B. V. S.	Thomas Goonetilleka	,, ,, 5·00

Matara District.

Bamunugama, B. V. S.	J. L. A. Davith	,, ,, 10·00
Deliyandara, B. V. S.	W. D. Peneris	,, ,, 5·00
Atureliya, M. V. S.	S. D. Kuruppu	,, ,, 5·00
Puhulwella, B. V. S.	H. A. Arnolis	,, ,, 5·00

Hambantota District.

Kiula, M. V. S.	P. P. Jandiris	,, ,, 5·00
Tissamaharama B. V. S.	M. J. James Jinadasa	,, ,, 5·00

Northern Division.

School Gardens.

Anuradhapura District.

Name of School.	Name of Teacher.	Award.
Galkiriyagama, B. V. S.	Y. N. Perera	Certificate and Rs. 15·00
Eppawela, V. M. S.	D. C. Goonetilleka	,, ,, 15·00
Kendewa, V. M. S.	T. B. Amunugama	,, ,, 15·00
Kahatagasdigiliya, B. V. S.	U. B. Dissanayaka	,, ,, 15·00
Topawewa, B. V. S.	W. Appuhamy	,, ,, 10·00
Tammuttegama, B.V. S.	H. M. Wannihamy	,, ,, 10·00
Horawapatana, B. V. S	N. Ranhamy	,, ,, 10·00
Kirigollewa, B. V. S.	B. M. Gunasingha	,, ,, 10·00
Galadiulwewa, B. V. S.	P. N. Jalisingho	,, ,, 10·00

Mannar District.

Iranai Illupaikulam, B. V. S.	K. Arumugam	Certificate and Rs. 15·00
Erukkilampiddy, B. V. S.	K. Alexander	,, ,, 15·00

Muillaitivu District.

Iratperiyakulam, B. V. S.	K. L. B. Dissanayaka	Certificate and Rs. 15·00

Trincomalee District.

Periyakinniyai, B. V. S.	C. Kopalapillai	,, ,, 15·00

Home Gardens.

Anuradhapura District.

Name of School.	Name of Pupil.	Award.
Kahatagasdigiliya, B. V. S.	Dinapala	Certificate and Rs. 5·00
do	P. K. Naida	,, ,, 2·50
Eppawela, M. V. S.	T. K. B. Kulatunga	,, ,, 5·00
Kendewa, M. V. S.	Dingiri Banda	,, ,, 5·00
do	D. A. Tennakoon	,, ,, 2·50
Galkiriyagama, V. B. S.	T. A. Herat Hamy	,, ,, 5·00
do	T. Tikiri Banda	,, ,, 2·50
Eppawela, M. V. S.	P. Menika	,, ,, 2·50

WESTERN PROVINCE.

Colombo District.

School Gardens.

Name of School.	Name of Teacher.	Award.
Kiriwattuduwa, B.V. S.	M. D. Peiris	Certificate and Rs. 20·00
Padukka, B. V. S.	G. D. de Silva	,, ,, 15.00
Padukka, G. V. S.	Mrs. D. M. Amarasinghe	,, ,, 15·00
Kesbewa, B. V. S.	G. C. Dabre	,, ,, 10·00
Malagala, M. V. S.	L. J. Perera	,, ,, 10·00

Colombo District.—*(Contd.)*
School Gardens.—*(Contd.)*

Name of School.	Name of Teacher.	Award.
Gehunuwela, B. V. S.	G. A. G. Perera	Certificate and Rs. 10·00
Urupola, B V. S.	D. A. Ranaweera	,, ,, 20·00
Kirindiwela, B. V. S.	M. L. Silva	,, ,, 15·00
Minuwangoda, A. V. B. S.	J. W. A. Jayawardana	,, ,, 15·00
Aluthepola, M. V. S.	D. P. Kannangara	,, ,, 10·00
Diulapitiya, B. V. S.	D. H. Jayasinghe	,, ,, 10·00
Pasyala, B. V. S.	M. V. Abeykkoon	,, ,, 10·00
Kurikotuwa. B. V. S.	D. B. Pivadasa	,, ,, 10·00
Keenadeniya, B. V. S.	H. D. Thegis	,, ,, 10·00
Alutgama B. V. S.	D. J. Perera	,, ,, 10·00
Aturugiriya, B. V. S.	D. D. Karunasekera	Certificate.

Home Gardens.

Name of School.	Name of Pupil.	Award.
Kesbewa, B. V. S.	A. Siridana	Certificate and Rs. 5·00
Bope, B. V. S.	Gunawardana Sinno.	,, ,, 5·00
Aturugiriya, B. V. S.	Carolis Sinno.	,, ,, 5·00
Aluthepola, M. V. S.	Bempy Perera	,, ,, 5·00
Padukka, G. V. S.	P. Nandawathie	,, ,, 5·00
Kesbewa, B. V. S.	Upasena Attygalle	,, ,, 2·50
Bope, B. V. S.	Aron Sinno.	,, ,, 2·50
Aturugiriya, B. V. S.	Sarnelis Fernando	,, ,, 2·50
Aluthepola, M. V. S.	Don Bastian	,, ,, 2·50
Padukka, G. V. S.	P. Pathmaperuma	,, ,, 2·50

NORTH-WESTERN PROVINCE.

Kurunegala District.
School Gardens

Name of School.	Name of Teacher.	Award.
Kankaniyamulla, M. V. S.	K. D. Peiris	Certificate and Rs. 20·00
Buluwela, B. V. S.	M. B. Weerakoon	,, ,, 15·00
Ambanpola, B. V. S.	K. D. Banda	,, ,, 15·00
Wariyapola, B. V. S.	H. H. Banda	,, ,, 10·00
Giriulla, B. V. S.	T. K. Nikaweratiya	,, ,, 10·00
Boyagana, B. V. S.	D. A. Perera	,, ,, 10·00
Wadakada, B. V. S.	W. Perera	,, ,, 10·00
Madagalla, B. V. S.	Don Frederick	,, ,, 10·00
Hettipola, B. V. S.	W. A. Senaratna	,, ,, 10·00
Balalla, B. V. S.	M. Punchirala	,, ,, 10·00
Atamune, B. V. S.	K. Kiri Banda	,, ,, 10·00
Narammala, B. V. S.	D. Kebilitigoda	,, ,, 10·00
Hunupola, B. V. S.	P. W. Premaratna	,, ,, 10·00
Polpitigama, B. V. S.	K. B. Herath	,, ,, 10·00
Borawewa, B. V. S.	T. B. Basnaike	,, ,, 10·00
Ehetuwewa, Boys'	U. B. Senewiratna	,, ,, 10·00
do Girls'	W. M. Mutumenika	,, ,, 10·00
Dieullewa, B. V. S.	K. B. Dissanayaka	,, ,, 10·00
Mahananneriya, B. V. S.	D. P. S. Deyale	,, ,, 10·00
Tambutta, B. V. S.	—	,, ,, 10·00
Bandara-Koswatta,	W. A. Banda	,, ,, 10·00

Kurunegala District.—(*Contd.*)

School Gardens (*Contd.*)

Name of School.	Name of Teacher.	Award.
Monnekulama, B. V. S.	H. D. Banda	Certificate and Rs. 10·00
Kirindewa, B. V. S.	W. S. P. Dharmawardana	,, ,, 10·00
Kuliyapitiya, B. V. S.	E. A. Dingiri Banda	,, ,, 10·00
Makandura, B V. S.	Romiel Perera	,, ,, 10·00
Wataraka, B. V. S.	D. Ratnayaka	,, ,, 10·00
Weuda, B. V. S.	D. S. Goonewardana	,, ,, 10·00
Gonigoda, B. V. S.	D. L. Banda	,, ,, 10·00
Meddegama, B. V. S.	W. W. Fernando	Certificate,
Kudakatnoruwa, B. V. S.	A. Kirihamy	,,
Itanawatta, B. V. S.	W. A. Kiri Banda	,,
Dahanakgedera, B. V. S.	N. Punchi Singho	,,
Udawela, B. V. S.	D. Jayasinghe	,,
Halmellewa, B. V. S.	M. Wijesinghe	,,
Awlegama, B. V. S.	H. M. Wariyapola	,,
Nikaweratiya, B. V. S.	P. B. Udalagama	Certificate
Poramadala Boys'	P. A. Senanayaka	,,
do Girls'	A. P. Perera	,,
Nakawatte, B. V. S.	K. D. J. Goonatilleka	,,
Nettipolagedera, B. V. S.	M. C. Silva	,,
Deegalla, B. V. S.	P. B. Marasinghe	,,
Pannala Boys'	T. A. Dingiri Banda	,,
do Girls'	Sumanawati Herath	,,
Weuda Girls'	D. Gunaesekera Menika	,,
Delwita, B. V. S.	R. P. Appuhamy	,,
Dodangaslande, B. V. S.	W. P. Appuhamy	,,
Ibbagamuwa, B. V. S.	A. K. Banda	,,
Medamulla, B. V. S.	H. M. D. Banda	,,

Home Gardens

Name of School.	Name of Pupil.	Award.
Wadakada, M. V. S.	Kirimudiyanse	Certificate and Rs. 7·50
do	Ran Banda	,, ,, 2·50
Kankaniyamulla, M. V. S.	Podiappuhamy	,, ,, 7·50
do	Manuel Hamy	,, ,, 5·00
do	Podia	,, ,, 2·50
Wadakada. M. V. S.	Herath	,, ,, 5·00
Deegala, V. B. S.	Dedrick Appu	,, ,, 5·00
Pannala, V. B. S.	A. M. Punchibanda	,, ,, 5·00
Nettipolagedera, B. V. S.	A. M. Punchibanda	,, ,, 5·00
do	Ausadhahamy	,, ,, 2·50
Meddagama, M. V. S.	Aramanis	,, ,, 5·00
Kuliyapitiya, B. V. S.	M. B. Herathhamy	,, ,, 5·00
do	E. John Singho	,, ,, 2·50
Wadakada, M. V. S.	Menikrala	,, ,, 2·50
Pannala, B. V. S.	S. A. Pabilis Perea	,, ,, 2·50
Meddagama, M. V. S.	Abadda	,, ,, 2·50

Puttalam, Chilaw Districts,

School Gardens

Name of School.	Name of Teacher.	Award.
Walahapitiya, B. V. S.	S. M. Jinadasa	Certificate and Rs. 20·00
Kirimatiyana, B. V. S	D. S. Weerakkody	,, ,, 15·00
Wekada, B. V. S.	D. K. Arangolla	,, ,, 15·00
Maiyawa, M. V. S.	K. D. G. Wickramasinghe	,, ,, 10·00
Walpaluwa, B. V. S.	A. Gunaratthamy	,, ,, 20·00
Mahakumbukkadawala, B. V. S.	S. N. D. Banda	,, ,, 10·00
Anamaduwa, B. V. S.	A. Abeykoon	,, ,, 10·00
Kelegama, B. V. S.	D. B. Marasinghe	Certificate

Home Gardens

Name of School.	Name of Pupil.	Award.
Mahakumbukkadawala, B. V. S.	K. C. Lapaya	Certificate and Rs. 2·50
do	K. R. Podiya	,, ,, 2·50
Walahapitiya, B. V. S.	Mendis Sinno	,, ,, 2·50
do	Podisinno	,, ,, 2·50
Kirimetiyana, B. V. S.	N. Rajapaksa	,, ,, 2·50
do	E. Ratnayaka	,, ,, 2·50

PROVINCE OF SABARAGAMUWA

Ratnapura District.

School Gardens

Name of School.	Name of Teacher.	Award.
Balangoda, B. V. S.	W. T. Banda	Certificate and Rs. 20·00
Karandana, B. V. S.	K. N. Thigoris	,, ,, 15·00
Malwala, M. V. S.	N. K. D. Cornelis	,, ,, 15·00
Godakawela, B. V. S.	M. James	,, ,, 10·00
Ilukkumbura, B. V. S.	H. K. Ratranhamy	,, ,, 10·00
Udagama, B. V. S.	A. D. Sineris	,, ,, 10·00
Nivitigala, M. V. S.	D. M. Gunawardana	,, ,, 10·00
Opanayaka, B. V. S.	D. B. Kotalawela	,, ,, 10·00
Ballekanda, B. V. S.	H. M. Tennekoon	,, ,, 10·00
Damahana, B. V. S.	G. James Sinno	,, ,, 10·00
Weddagala, M. V. S.	L. D. Abraham	,, ,, 10·00
Balangoda, G. V. S.	Mrs. K. Sampohamy	Certificate

PROVINCE OF UVA.

School Gardens

Name of School.	Name of Teacher.	Award.
Tennepanguwa, B. V. S.	R. M. K. Karunaratna	Certificate and Rs. 20·00
Beranade, B. V. S.	P. A. K. Banda	,, ,, 20·00
Medagama, B. V. S.	V. S. Appuhamy	,, ,, 20·00
Passara, M. V. S.	J. D. S. Senanayaka	,, ,, 15·00
Wangiyakumbura, B. V. S.	L. D. Lewis	,, ,, 10·00
Etampitiya, B. V. S.	William Banda	,, ,, 10·00
Kalupahana, B.V. S.	C. Ranasinghe	Certificate

Home Gardens

Name of School.	Name of Pupil.	Award.
Tennepanguwa, B. V. S.	M. B. Ratnayaka	Rs. 5·00
Passara, M. V. S.	D. D. Charles Sinno	,, 5·00
Medagama, B. V. S.	Bastian Perera	,, 5·00

EASTERN PROVINCE.

School Gardens

Name of School.	Name of Teacher.	Award.
Olivil, B. V. S.	V. Pattacuddy	Certificate and Rs. 10·00
Synthamarathu, B. V. S.	T. S. Candiah	,, ,, 10·00
Oddaimawadi, B. V. S.	V. Sinnathamby	,, ,, 10·00
Kattankudi, B. V. S.	K. E. Vellupillai	Certificate
Irakkaman, B. V. S.	K. Poowalipillai	,,
Eravur, B. V. S.	A. Sangarapillai	,,

Home Gardens

Name of School.	Name of Pupil.	Award.
Kattankudi, B. V. S.	A. Mamadu Ismail	Certificate and Rs. 5·00
Nindoor, B. V. S.	C. Mamadu Ibrahim	,, ,, 5·00

THE PADDY FIELDS AND VEGETABLE GARDENS COMPETITIONS IN UVA.

The following awards have been made by the Food Production Committee, Uva, from Grants made by the Department of Agriculture in connection with Paddy Fields and Vegetable Gardens Competitions in 1920-21 :—

There were 64 entries. The judging was done by the Agricultural Instructor and the Chief Headman of the division concerned.

PADDY FIELDS—MANURED AND TRANSPLANTED.

1st Prize Rs. 20

Division.	*Name of Winner.*	*Address.*
Udukinde	K. B. Kadurugamuwa	Bandarawela
Yatikinde	G. D. E. Rodrigo	Gawarawela
Bintenne	S. H. Heen Appu	Alutnuwara
Wellassa	H. T. Appuhamy	Makulla

2nd Prizes of Rs. 10

Udukinde	Punchirala	Bandarawela
Yatikinde	H. C. Wijesinghe	Badulla
Bintenne	Y. Kiri Banda	Mahagama
Wellassa	K. H. M. Sudu Banda	Dahagomiya

VEGETABLE GARDENS.

Prize of Rs. 12·50

Udukinde	K. M. Idroos	Padinawela
Yatikinde	G. Menikrala	Hinnarangolle

CHENA GARDENS.

Prize of Rs. 12·50

Wiyaluwa	P. Sudu Banda	Meegahakeula
Bintenne	Hendrick Sinno, Vel-vidane	Alutnuwara

VEGETABLE GARDEN WITHIN LOCAL BOARD LIMITS.

Prize of Rs. 12·50

Local Board	T. S. Selviah	Badulla

POTATO GARDEN.

Prize of Rs. 10·00

Udukinde	K. M. Zubair	Padinawela

J. AUSTIN RAMBUKPOTA,
A. I.

APICULTURE.

BEESWAX:

METHODS OF EXTRACTION, AND THE PREVENTION OF WASTE.

W. HERROD-HEMPSALL.

Wax is not gathered by the worker bee, but is organically produced in her body from honey and pollen, by secretion. It is formed voluntarily by the bees filling their stomachs with honey, hanging in the hive in chain-like clusters, and remaining perfectly quiet for twenty-four hours. A good deal of pollen is consumed to make up for the wear and tear of tissue during wax secretion. During this period the wax glands convert the honey taken into their bodies into liquid wax, which exudes through tiny perforations into eight small pockets, or moulds, situated on the underside of the last four abdominal segments, where it hardens into small white scales. It is then plucked out, made plastic by the admixture of saliva, and utilised for the building of the comb, the hermetic sealing of honey cells, and, with the addition of pollen, for the porous sealing of brood cells. It is computed that from ten to twenty pounds of honey are required to make one pound of wax. The work of wax secretion tells severely upon the vital powers of the bee, and being a valuable and costly product, none of it should be wasted.

When cleaning hives or appliances, a box should be kept for the collection of all refuse and burr combs. The scrapings from the floor board, which are generally thrown on the ground during spring cleaning, should be saved, although they contain a quantity of dirt and propolis, for there is generally sufficient wax to make it worth the trouble of collection and extraction. The honey combs used for extracting do not wear out, but last indefinitely; brood combs, on the contrary, become thickened by the cocoons and cast skins of the moulting larvæ, and must be continually renewed. Wax can therefore be obtained from old brood combs and the cappings from extracting combs.

Methods of Extraction.—The extraction of the wax may be made by using:—

(1) The Solar Wax Extractor
(2) Steam
(3) Boiling water
(4) The heat of the oven

The most efficient and economical method is the first. The cost of the extractor is the only expense incurred, as the sun provides the necessary heat. The appliance is really a miniature garden frame, with a double glazed and hinged light. Inside, the frame is fitted with a metal tray which slopes down to a tin trough covered with wire gauze. The extractor is placed in a sunny position and the material to be treated is spread thinly over the bottom of the metal tray. The wax melts and runs into the trough,

being strained of impurities by the wire gauze covering. When the melted wax ceases to flow, the dross remaining in the tray is removed and a fresh supply of material given. Another advantage of this extractor is that no storage of old combs or refuse is necessary ; these can be put in for treatment as collected.

If a garden frame is available, it can be used for extracting wax by placing the material to be treated in a perforated zinc tray over a metal box (such, for instance, as a biscuit tin), placed close up to the glass light. Wax extracted by solar heat improves in colour instead of deteriorating, as it may do when steam or boiling water is used.

The material to be extracted by methods (2) and (3) must be stored until required, in an air-tight tin, for protection against the ravages of the wax moth. In the winter it can be melted over the kitchen fire by means of a Gerster wax extractor. This is an arrangement similar to a domestic steamer. It consists of a cylindrical, perforated, tin basket, having a cone-shaped tube running up the centre, which is also perforated, and open at the top to allow the steam to percolate right through the combs or wax that are placed in it for melting. The upper part of the appliance consists of a circular shaped pan, having a false bottom or tray about 1½ in. deep. This its fixed so that there is a space between it and the wall of the pan, in order that the steam can pass up the sides and into the perforated basket.

From this tray the melted wax passes through a tube. There is also a cone-shaped tube running up from the tray, which fits very loosely into a similar perforated tube in the basket. When placed in position, this is open at the top to allow the steam to pass through, and thus permeate the wax or combs in the basket. The basket does not fit close down on the tray, but is raised about 1 in. on three legs. The bottom pan is for water only.

The method of working is as follows :—The perforated basket is filled with comb which has first been broken into small pieces ; these should not be pressed down, but put in as loosely as possible. The basket is placed in position in pan, and covered with the lid. Pan is now fitted on pan which has previously been filled with rain water. The appliance is then put on the fire, and when the water boils the steam will pass in the directions indicated and will melt the wax from the combs in the perforated basket. The molten wax will ooze out through the perforations, run down the sides of the basket into the tray, and thence out of the tube, where it drops into cold rain water, contained in a vessel placed for the purpose of receiving it. As soon as it is cold, the wax will be found to have set in a cake, when it can be lifted off. When all the wax has been extracted the dross is removed from the basket and the process repeated.

As the water boils away very rapidly it will be necessary to replace it from time to time ; by means of the funnel this can be done without removing the appliance from the fire.

Cappings from the shallow combs, when cut off for extracting the honey, can also be melted in the same manner. Before putting them in the basket, however, they should be drained free from honey, well washed in rain water, and dried in the sun.

A cheaper form of wax extractor is made on similar lines to the Gerster, but the cost is reduced by omitting the central cone-shaped tube ; in all other respects it is identical. As steam is not admitted into the centre of the perforated wire basket, the operation of extraction is prolonged.

To extract wax by means of boiling water, the material should be tied in a bag made of porous fabric, such as cheese straining cloth, and stood on laths of wood placed across the bottom of a copper or saucepan, so that the bag does not touch the bottom. The bag should be weighted with a stone, and water then poured in until it flows above the bag. The water should then be boiled very gently. The melted wax will percolate through the bag and float on the water, and when cold it can be lifted off in a solid cake. A little dross will be found on the bottom of the cake, but this can be removed by scraping. If a well-cleaned sample is desired, the cake should be remelted in a similar manner, and cooled slowly. Rain water must be used in methods 2 and 3, as hard water contains lime, which would spoil the texture and colour of the wax. More wax will be obtained if pressure is applied to the bag while boiling, and in the case of old combs, if these are well soaked in water previously to melting.

If only a small quantity of wax is to be dealt with, it may be placed on a piece of perforated zinc over a bowl of rain water, and put in the oven. The wax will melt and drop through the perforated zinc into the water ; the impurities will remain on the zinc and can be thrown away. The bowl is then taken out of the oven and the water and wax allowed to cool, when the latter will have set in a cake and can be lifted off.

The melting point of pure beeswax is between 63° and 64°C., which is higher than that of any other wax. The colour, which varies from pale primrose to orange red, depends to a greater extent upon the variety of pollen consumed by the bees. It is a curious fact that dark honey produces a light wax, while light honey yields one of a darker hue.

For commercial purposes the lightest coloured wax commands the best price, and therefore, before extracting, it is advisable to grade the combs. Those which have not been occupied by brood, and also cappings removed from combs previous to extracting the honey, will yield the best wax, and should be sorted out and melted separately from old combs, which will yield a darker and consequently less valuable wax.

It is unfortunately a fact that adulteration of beeswax sometimes occurs. The materials used for this purpose include tallow, stearin, paraffin, vegetable wax, resin, and ozokerit. Owing to their low melting point, the addition of any of these to beeswax used for making comb foundation is disastrous in its effect. The following are simple tests for detecting adulteration :

(1) A small piece of wax placed in the mouth and chewed should not adhere to the teeth, or become pasty, but, generally speaking, should disintegrate into small fragments, and have no unpleasant taste.

(2) Place a piece of suspected wax (of the size of a small nut) into a test tube, half fill with spirits of turpentine, and carefully warm over the

flame of a spirit lamp. If the solution is cloudy, or a deposit is thrown down, the solution is not complete, and the wax is adulterated, as spirits of turpentine completely dissolves pure beeswax.

A large quantity of wax is imported into this country from Germany, Holland, Madagascar, Chili, Brazil, and various other countries. The value of the importations in 1919 of beeswax, ozokerit, and earth wax was £1,045,415 of which the greater portion was probably beeswax. It is important, therefore, that none of this valuable material should be wasted, for when recovered and sold it will reduce to a considerable extent the large sum of money hitherto spent on its importation. Further, by saving wax and having it made into comb foundation for his own use, the bee-keeper will add considerably to the profits of the apiary; the cost of manufacture is trifling compared with the price that has to be paid for the finished article.

Beeswax is used commercially for the following purposes:—

Comb foundation for bee hives
Grafting wax for fruit trees
Furniture and floor polish
Water-proofing packing paper
Boot polish and dubbing
Candles for churches
Plaster casting
Cosmetics
Salves
Stopping teeth and making mouth models.

Journ. of Ministry of Agric., Vol. XXVIII, No. 4.

UNITING COLONIES OF BEES.

W. A. GOODACRE.

Senior Apiary Inspector.

A good method for uniting colonies of bees is as follows:—

Late in the afternoon, the queen should be removed from the weakest stock and after the bees have settled down the hive should be carried to the one with which it is to be united. Remove the cover from the hive on the permanent stand and place a sheet of newspaper over the frames; the removed colony is then freed of its bottom board, and placed on the paper over the permanent hive. The bees will unite gradually through holes they will make in the paper, and there should be no fighting or balling of the queen. In a few days' time the colony can be made compact.

Weak colonies can generally be united with success by carefully lifting out the frames containing bees from the hive made queenless and placing them direct in a space made to receive the frames in the hive they are to be united with. Do the work about dusk and be careful not to excite the bees more than is necessary.—Agric. Gaz., N. S. W., Vol. XXXII, Part 8.

CO-OPERATION.

REPORT ON THE TRAINING CLASSES FOR HONORARY SECRETARIES AND OTHER WORKERS OF CO-OPERATIVE CREDIT SOCIETIES.

The training classes were held from April to May and from August to September. The following are the centres at which the classes were held viz :—Kalutara, Horana, Matara, Galle, Colombo, Heneratgoda, Anuradhapura, Kandy, Badulla and Jaffna.

2. At Kalutara the classes were held at the Town Hall and the Assistant Government Agent, Kalutara, opened the classes. The Registrar delivered an introductory address. Representatives from 18 societies attended the classes. The Registrar Mr. Clement O Wijeratne ; Mudaliyars Edmund Peiris and D. T Perera presided at the different sessions. At Horana the classes were held at the Buddhist English School. The Divisional Agricultural Officer, Southern Division opened the classes Mr. P. A. Gunaratne gave an address. The Divisional Agricultural Officer, Mudaliyar J. D Emalian and Muhandiram Wickramanayaka presided at the different sessions. 13 societies represented at this centre.

3. Training classes at Matara were held at the Wesleyan Methodist English School, Fort, and were opened by the Assistant Government Agent, Matara. 14 societies from Matara and Hambantota sent in their representatives. Mudaliyar W. A. Amerasekera, Mudaliyar W. A. Perera, Revd. W. G. Mendis and Revd. Ward presided at the different sessions.

4. At Galle the classes were held on the first day at the Headmen's lodge. The Government Agent, Southern Province, opened the classes. The Divisional Agricultural Officer, Southern Division, gave an address. On subsequent days the classes were held at the office of the Divisional Agricultural Officer. 12 societies represented at the classes. Mudaliyars E. B. Gunatilake, A. E. Gunatilaka, G. A. Gunatilaka and C. P. Wanigatunga presided at the different sessions.

5. At Colombo the Government Agent, Western Province, opened the classes held at Ananda College. The Registrar addressed the representatives present. Mr. W. A. de Silva and Dr. C. A. Hewavitarana also spoke. Six societies were represented. Gate Mudaliyars C. H. A. Samarakoddy, J. A. Wirasinha and Mr. P. de S. Kularatne, M.A., Principal of Ananda College, presided at the different sessions

6. At Heneratgoda classes were held at the Buddhist English School and opened by the Government Agent, Western Province. The Registrar delivered an introductory address. Ten societies represented. Mudaliyars J. P. Obeysekere, T. F. Abeykoon, C. H. A. Samarakoddy, Mr. Peter Wirasekera and Mr. E. W. Kannangara C.C.S. presided at different sessions. Those gentlemen and Messrs. D. M. P. R. Senanayaka and D. J. Jayawardene spoke on the subject. A number of Vel Vidanes from Uruwel Peruwa attended the classes.

7. The classes at Anuradhapura were held at the Roman Catholic English School and were opened by Mr. Phillipson, the Office Assistant to the Government Agent, North-Central Province. The Divisional Agricultural Officer, Northern Province, and the Hon'ble Mr. S. D. KrisnaRatne delivered short addresses on Co-operative Credit Societies. Six societies represented in addition to a number of minor headmen.

Bulankulama Dissawa and Mudaliyar Tennekoon presided at the different sessions.

8. The Kandy classes were held on the first and the last day at the Town Hall and on the second day at the Audience Hall. The Government Agent, Central Province, opened the classes. The Registrar was present and spoke on the Co-operative Credit movement. A large representative gathering of Chief Headmen and leading residents were also present at the opening. 20 societies represented. Messrs. R. W. Paranagama Ratemahatmaya, H. D. Keppitipola, Ratemahatmaya, V. B. Uduwawela Ratemahatmaya and W. Madawela Ratemahatmaya presided at the different sessions. Some of the Chief Headmen who are interested in the movement also attended the classes.

9. At Badulla the classes were held at the Town Hall and were opened by the Government Agent, Uva Province. The Registrar gave an address on co-operation. The Hon'ble Mr. D. H. Kotalawala and Mr. H. J. Pinto also spoke. Five societies represented at the classes. Messrs. Rambukpotha, Ratemahatmaya, H. B. Katugaha, Retemahatmaya and Mudaliyar Tillekeratne presided at the different sessions.

10. The last of the classes were held at the Sales Room of the Kachcheri, Jaffna, and were opened by the Government Agent, Northern Province. The Divisional Agricultural Officer, Northern Division, addressed the gathering at the opening of the classes. Mr. A. A. Ward, President of the American Mission Agents' Co-operative Society also spoke. A large number of leading residents, viz : Sir Ambalavanar Kanagasabai Kt., Messrs. A. Sabapathy, N. Selvadurai, Revd. Father Soullier, Sister Gertrude, Mudaliyar V. M. Muttukumaru, Maniagars J. N. Sandrasekera, K. Chinnatamby, Mudaliyar Ramalingam were present. 15 societies represented at the classes.

11. At all these centres the Agricultural Instructors, minor headmen and few representatives of the general public attended the classes.

12. The Secretary, Board of Control Co-operative Credit Societies, conducted the classes at all centres. At Jaffna he was assisted by the Tamil Inspector and at Kandy by the two Sinhalese Inspectors. Five to six hours were occupied each day divided into sessions. Morning sessions from 8 to 11 a.m. and afternoon sessions from 2 to 4 and sometimes 5 p.m. At some of the centres the hours had to be altered to suit the convenience of those attending the classes.

13. The following are the subjects on which lectures were given :—

(1) The Co-operative Credit Societies' Ordinance, Rules and By-laws.
(2) Types of Co-operative Societies.
(3) Organisation of a Co-operative Credit Society.
(4) Management of a Society,
(5) Books and Forms of a Society.
(6) Accounts.
(7) Preparation of an annual Balance Sheet.
(8) Inspection and audit of a Society.

14. On questions by those attending the classes, complete revision of lectures given. Verbal examination and visiting of a Co-operative Credit Society in session are the other items included in the time table. At some of the centres arrangements could not have been made to visit a society in session.

15. At these lectures those attending took notes. At the end of each lecture they were given time to put questions to the lecturer. This created a series of useful discussions on important points and much useful information was diffused. Many intricate questions were raised, discussed and explained. The exchange of ideas and opinions as to the success and failures of the societies helped to indicate the weak points in the working of societies. Some of the questions raised indicated the interest taken by those who attended the classes in the lectures.

16. The following table shows the particulars of attendance at each of the centres :—

Centre.	Societies represented No. of	No. of representatives.	No. of visitors.	Centre.	Societies represented No. of	No. of representatives.	No. of visitors.
Kalutara	18	40	17	Heneratgoda	10	21	21
Horana	13	28	13	Anuradhapura	6	16	23
Matara	14	27	7	Kandy	20	64	20
Galle	13	28	9	Badulla	5	8	6
Colombo	6	12	6	Jaffna	13	24	15

Summary.

The number of societies represented was	118
The number of Secretaries and Treasurers etc.	268
The number of visitors	137

17. The attendance at all the classes except at Colombo was satisfactory. The classes arranged to be held at Kegalle had to be abandoned as the attendance was not satisfactory owing to the date being unsuitable. The office-bearers of these soci ties attended the classes held at Kandy subsequently.

18. The invitation of the Government Agent, Eastern Province, and the Assistant Government Agent, Trincomalee District, to hold the classes at their centres had to be postponed for next year. No classes were held at Ratnapura and those representatives of societies in the District should be given an opportunity to receive a training. Of the societies in the North-Western Province, the Marawila and Hirial Hat Pattu sent in their representatives to Colombo and Kandy respectively.

19. At Kandy two resolutions submitted by Messrs. T. B. Ellepola, Ratemahatmaya and Mr. J. C. Wimalasiri, Secretary of the Sinhalese Young Men's Association and supported by Mr. L. D. Alwis, Secretary, Matale East Society, urging the necessity of holding the training classes annually and the publication of a hand-book on co-operation respectively were carried. At Kalutara a resolution on the desirability of the publication of instructions on the working of Co-operative Credit Societies in the vernacular was also passed. At Jaffna the desirability of making the classes an annual event was moved and passed.

20. The classes were on the whole a success. Those who attended the classes have appreciated their usefulness and have borne testimony to the interest created among the workers. As a result the work of some societies is showing to be more systematic.

21. Our thanks are due to the Government Agents, Assistant Government Agents and the Chief Headmen for the assistance rendered in the arrangements of holding classes and also to those who presided at the classes and placed the buildings at our disposal for the holding of classes.

22. The Secretaries and Treasurers and other workers deserve the thanks of the Department and of the general public for ungrudgingly responding to our requests and attending the classes for three days at much inconvenience and expense to themselves. Some of those who attended classes had to come from distant places from 20 to 30 miles where no public conveyances are available.

23. It has been proposed to issue certificates to those who attended the full course of training and there is already a demand for them. I would suggest that arrangements be made in future to offer prizes to those attending the classes and if this is adopted I am sure the public would subscribe for the formation of a prize fund. I would also suggest that conferences be held in future on the last day of the classes so that the members may read reports of societies, discuss the possibilities of extension and exchange ideas etc., as such conferences will go a great way to further the interest of these societies.

N. WICKRAMARATNE,
Secretary, Board of Control Co-operative Credit Societies.

1st October, 1921.

GENERAL.

BREEDING DISEASE-RESISTANT PLANTS.

Dr. J. TH. UPHOF, BUSSUM, HOLLAND.

The breeding of disease–resistant races of plants for horticultural and agricultural purposes offers a very promising field for the scientific investigator as well as for the cultivator. Plant breeding on these lines is of comparatively recent date, but has already brought to light several important data on which we are able to build our future work successfully.

Diseases may be controlled by treating plants and seeds in various ways. as well as in changing environment and the time of planting ; but although infection may be lessened in this way, these methods will not make the plants immune to fungus or bacterial diseases.

The expenses of combating diseases are considerable ; whereas the losses caused annually by diseases are tremendous. Therefore this line of breeding requires much consideration.

Immunity and susceptibility to disease are not yet perfectly understood, but it is certain that immunity is largely governed by biochemical characters of the cells, which protect the plant body against attacks of various parasites. No doubt the subject of immunity is a complicated one, especially when we remember that a variety of a certain species may be immune from attacks of one disease and not from another. The Centerville Cotton of the Sea Island Group is resistant to will (*Fusarium vasinfectum*) and bacterial blight (*Bacterium malvacearum*), whereas the variety Rivers is susceptible to blight but resistant to will. Other plants may be extremely resistant to cold, yet easily susceptible to a fungous disease. Ward and Salmon have demonstrated that germinating spores of fungi may penetrate certain plants they cannot act upon parasitically, and are killed by the plant cells they attack.

Another question arises, namely, whether disease-resistance remains equally constant in different localities. And yet another may be considered, i. e., whether a disease-causing-fungus is able to develop an active strain which may cause infection upon varieties regarded as resistant.

How nature must have bred resistant strains of plants is a point of great interest. I will give a few striking examples.

The Phylloxera (*Phylloxera vastatrix*) is a pest upon the leaves and especially the roots of all varieties of the European Grape and Asiatic species of Vitis. This insect came originally from the eastern part of the United States, where most Vitis species are more or less resistant. No doubt in the struggle for existence, several strains of the Wild Grape were unable to resist the damage done by Phylloxera and succumbed, while only the most resistant ones were able to survive. The various known forms of Vitis species of the old world are unable to resist the attacks of this new enemy, especially on their roots, for which reason cultivated varieties are often grafted on American species.

A similar case is the American Gooseberry Mildew, caused by Sphæroтheca mors-uvæ. This fungus is extremely destructive upon practically all varieties of the European Gooseberries, whereas American species are far less susceptible.

An instance of susceptibility to the very destructive bark disease caused by Diaporthe parasitica, is to be found with the European and American Chestnuts. Thousands of trees are killed yearly in the eastern part of the

United States. The fungus is of Asiatic origin, where it is a harmless parasite of the indigenous species of Chestnuts, such as *Castanea Mollissima.*

These data suggest crossing desirable, though susceptible species or varieties with resistant ones to obtain disease-resistant and further desirable economic forms, otherwise an entirely new parasite may become virulent on account of the absence of resistant qualities in the new host plant.

As it has been suggested that disease-resistance and disease-susceptibility may depend upon the presence or absence of one or more characters, it might be readily expected that, after hybridising, either resistance or susceptibility should be dominant in the first hybrid generation ; whereas in further generations they should split according to MENDEL's Law. This is actually the case. But some of the results are such that far more attention must be paid to this phenomena. BIFFEN discovered, in crossing the rust-resistant Rivet Wheat and the highly susceptible Red King, that disease-resistance is in this case recessive in the first hybrid generation, whereas other investigators observed in other plants that resistance is dominant. With few exceptions, disease-resistance depends upon the absence or presence of one character of the host.

Disease-resistant strains, produced either by hybridisation or by selection, include the following :—

Rust on Asparagus caused by *Puccinia asparagi* has been a great trouble in several parts of the United States ; therefore, in 1906 the Massachusetts Asparagus Growers' Association secured the co-operation of the Bureau of Plant Industry of the U.S. Department of Agriculture and the Massachusetts Agricultural Experiment Station in conducting experiments to obtain a rust-free strain of Asparagus. Varieties from the Old and the New World were collected and observed as to their resistance to rust ; in 1908 and 1909 pedigree seed from the most resistant plants were secured ; in 1910 the seedlings showed one male plant, which was rust-resistant. A female plant, a seedling of Reading Giant, was crossed with this male, and gave excellent progeny ; the first-named strain was called Martha Washington. The parent plants, and also other excellent sorts, were afterwards removed to the Arlington Experiment Farm near Washington, D.C., where breeding was continued. Large numbers of pedigree seedlings have been obtained each year, and the rust-free Washington Asparagus has proved a success. NORTON found in this case that resistance in the first generation proved dominant over susceptibility.

The control of Cabbage Yellows (caused by *Fusarium conglutinans*) has been worked out by JONES and GILMAN in the State of Wisconsin. This Cabbage trouble is widely scattered in Wisconsin ; the fungus attacks the roots either in the seed-bed or shortly after transplanting. Such plants are stunted, the leaves become pale and yellowish, and the plants succumb after a few weeks. The disease is very destructive after a period of dry, hot weather following transplanting. The loss frequently amounts to from 50 to 75 per cent. Careful study revealed that various pure lines selected from so-called "commercial varieties" had various tendencies towards Fusarium attacks, which remained constant in the offspring ; some were very susceptible, whereas others proved extremely resistant. A very large number of these strains was observed for several years, and finally the variety Wisconsin Hollander No. 8 proved to be the most desirable.

Quite recently NILSON-EHLE published in the new Swedish periodical *Hereditas* very interesting accounts of his observations on Root-knot (*Heterodera Schachti*) on certain varieties of Barley. He found that some varieties, such as Chavalier I, Chavalier II and Primus, were immune, but Princess and the Four-rowed Barley of Schonen were susceptible to a considerable extent. After careful hybridisation it proved always in the first generation that immunity was dominant, and the progeny in the second and

third hybrid generations showed clearly that segregation was based upon only one unit character.

Though Root-knot is practically harmless to Barley, it is of immense advantage to have varieties free from Root-knot when Oats are to be the succeeding crop. So far as our present knowledge is concerned all Oats are susceptible to Root-knot, which causes much damage to the crop.

Breeding disease-resistant plants will, no doubt, become of as much importance as breeding for increase of production. This field of observation and experiment forms the borderland, where students of genetics and plant pathologists will have to work in complete harmony if the best results are to be expected.—Gardeners' Chronicle, Vol. LXIX, No. 1,797.

SAND AS A MEDIUM FOR PROPAGATING CUTTINGS.

It is still the general practice in gardens where a considerable amount of propagation is done to use the orthodox mixture of loam, leaf-mould, and sand. Success is doubtless assured by this means, and everyone is naturally rather chary of trying newer methods when there is always the element of uncertainty. I am not here advocating anything new, nor is it my own idea but I am so convinced of the merits and advantages of propagation by the use of sand that I would like to see it more generally adopted.

First I will explain the method and will presume that I am propagating a batch of Chrysanthemums from cuttings. The usual plan is to prepare sixty-sized pots by washing, drying, and draining them, and then making a mixture of loam, leaf-mould, and sand for filling the pots. A little sand is scattered over the surface, and the cuttings, after being trimmed, are dibbled in and made firm. Compare this with the sand method. A box or propagator in a cool-house is cleaned and a layer of leaves or leaf-mould is put in the bottom. This is covered with about 3 inches of sand sifted through what is known as a sand sieve, and, when pressed and made even, is watered with a fine-rosed can, so that all the sand is saturated. When the surplus water has drained away, the cuttings may be inserted. The cuttings are trimmed in the usual way, and are simply pressed into the wet sand, which obviously is a much quicker method than putting them in with a setting peg and firming them. To ensure the sand pressing closely against the stems, a further watering is given immediately after the cuttings are inserted. Where the stems are not sufficiently firm to admit of their being pressed into the sand, I always put them in by using the blade of a small budding knife, merely making a hole and, after putting in the cuttings, pressing the sand back being satisfied that the subsequent watering will wash the sand closely against the stems. The sand should not be allowed to become dry, but there is less danger from over-watering than in the case of mixed soil. When the cuttings have rooted, they may be removed from the moist sand without breaking a single root. I have use sand also for sowing seeds of Tomatos, Stocks, and Asters, being of opinion that in the young stage only moisture and a porous, aerated soil is needed. If pricked off early, I find that seedlings thus raised become quite as good plants as those sown in mixed soil. I claim for sand propagation that a porous compost is ensured. There is no mixing of soil, no need to use a dibber, no breaking of roots, and no damping off.—W. R. Gardeners' Chronicle, Vol. LXX, No. 1801.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31st OCTOBER, 1921.

Province, &c.	Disease.	No. of Cases up to date since Jan. 1st 1921.	Fresh Cases	Recoveries.	Deaths.	Balance Ill.	No. Shot.
Western	Rinderpest	—	—	—	—	—	—
	Foot-and-mouth disease	83	—	83	—	—	—
	Anthrax	—	—	—	—	—	—
Colombo Municipality	Rinderpest	—	—	—	—	—	—
	Foot-and-mouth disease	91	—	—	—	—	—
	Anthrax	—	—	—	—	—	—
	Rabies	2	—	—	—	—	—
Cattle Quarantine Station	Rinderpest	7	7	—	—	—	—
	Foot-and-mouth disease	51*	—	—	—	—	...
	Anthrax	347†	13	—	—	—	...
Central	Rinderpest	—	—	—	—	—	—
	Foot-and-mouth disease	14	1	13	—	1	—
	Anthrax	—	—	—	—	—	—
	Piroplasmosis	15	2	8	5	2	—
Southern	Rinderpest	—	—	—	—	—	—
	Foot-and-mouth disease	35	—	35	—	—	—
	Anthrax	—	—	—	—	—	—
Northern	Rinderpest Foot-and-mouth disease Anthrax	Free					
Eastern	Rinderpest	—	—	—	—	—	—
	Foot-and mouth disease	245	4	223	9	13	—
	Anthrax	—	—	—	—	—	—
North-Western	Rinderpest	36	—	11	23	—	2
	Foot-and-mouth disease	—	—	—	—	—	—
	Anthrax	—	—	—	—	—	—
North-Central	Rinderpest Foot-and-mouth disease Anthrax	Free					
Uva	Rinderpest	—	—	—	—	—	—
	Foot-and-mouth disease	402	1	392	10	—	—
	Anthrax	—	—	—	—	—	—
	Hæmorrhagic Septicæmia	20	—	2	18	—	—
Sabaragamuwa	Rinderpest	—	—	—	—	—	—
	Foot-and-mouth disease	42	42	27	—	15	—
	Anthrax	—	—	—	—	—	—

* 7 cases occurred amongst sheep and goats. † occurred amongst sheep and goats.

G. W. STURGESS,
Government Veterinary Surgeon.

Colombo, 2nd November, 1921.

METEOROLOGICAL.

OCTOBER, 1921.

Station	Temperature: Mean Daily Shade	Temperature: Difference from Average	Mean Humidity	Mean amount of cloud 0=clear, 10=overcast	Mean Wind Direction during month	Daily Mean Velocity.	Rainfall: Amount	Rainfall: No. of Rainy days	Rainfall: Difference from Average
	°	°	%			Miles.	Inches		Inches
Colombo Observatory	80·8	+ 0·6	82	8·5	WSW	99	8·44	26	- 5·04
Puttalam	80·8	0	81	6·0	SW	142	9·33	18	+ 0·43
Mannar	83·1	+ 0·7	74	8·0	WSW	143	8·59	16	+ 0·73
Jaffna	81·6	0	82	7·2	Variable	194	11·10	15	+ 1·81
Trincomalee	82·2	- 0·3	80	7·5	Variable	140	11·44	18	+ 3·48
Batticaloa	81·6	- 0·1	78	5·4	N	147	6·59	15	+ 0·22
Hambantota	80·4	0	84	6·3	SW	239	9·07	12	+ 4·34
Galle	79·6	0	85	6·6	W	201	12·32	25	- 1·11
Ratnapura	80·1	+ 0·1	83	7·7	—	—	18·64	26	- 0·37
Anu'pura	80·6	- 0·8	78	6·9	—	—	17·36	19	+ 7·67
Kurunegala	80·2	- 0·1	81	7·4	—	—	12·77	24	- 2·65
Kandy	75·9	+ 0·1	86	7·3	—	—	12·44	24	+ 0·72
Badulla	73·7	- 0·6	84	8·0	—	—	14·28	28	+ 4·72
Diyatalawa	67·8	- 0·6	84	7·3	—	—	10·51	25	+ 0·29
Hakgala	61·2	+ 0·3	89	8·6	—	—	11·66	24	- 0·39
N. Eliya	61·0	+ 1·4	86	8·6	—	—	11·68	28	+ 0·72

In the northern half of the island the October rainfall was above average, Vadamarachchi and Point Pedro leading with 24·1 inches and 20·7 inches respecively. If we take the southern half of the island as south of a line from Chilaw to Batticaloa we can subdivide it into two main divisions by a north and south line from Dambulla to a point between Matara and Tangalle. West of this line most stations were below average including deficits of more than 5 inches in the Colombo district, in the Hatton-Maskeliya area, and in a few other stations in the Kelani Valley and Southern Province. East of this line most stations were above their average, excesses of 5 inches being common in the Eastern Province and Uva, while at the south east shoulder of the hills near Koslanda several stations were more than 10 inches ahead, including Udahena 29·2 inches and Meeriabedde 26·3 inches while further East Walton Estate had 31·8 inches and Monaragala Hospital 25·6 inches.

As regards distribution in time during the month, the heaviest rain was probably about the 9th though as is usual in this month, much of the rain came in the form of vigorous local thunderstorms giving considerable variation between adjacent stations both in quantity and date.

The variation in pressure between different parts of the island was rather less than usual for October and hence the wind velocities were also below average, though the cloud-amounts were above it and humidity was above except on the west coast.

Temperature offsets were for the most part small; Nuwara Eliya alone being more than a degree from average.

A. J. BAMFORD,
Supdt. Observatory.